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A UNIQUE DEPARTURE IN ENGINEERING EDUCATION.

By Prof. EDWARD ORTON.

THE Ohio State University, located at Columbus, O., has sent to this office the handsome illustrated catalogue of its College of Engineering, in which is presented to the public a feature of engineering education which we think so novel and so interesting that we have secured a more extensive account of it for our readers.

The word ceramic is not a common one, and when used it generally suggests finely decorated and artistic glass and pottery ware. A course in ceramics, by inference dealing with the production and especially the decoration of this sort of material, seems to most people entirely incongruous with the purpose of an engineering school, which is characterized above most other branches of education by exactness and rigid adherence to facts, and by neglect of everything that partakes of the imaginative or artistic.

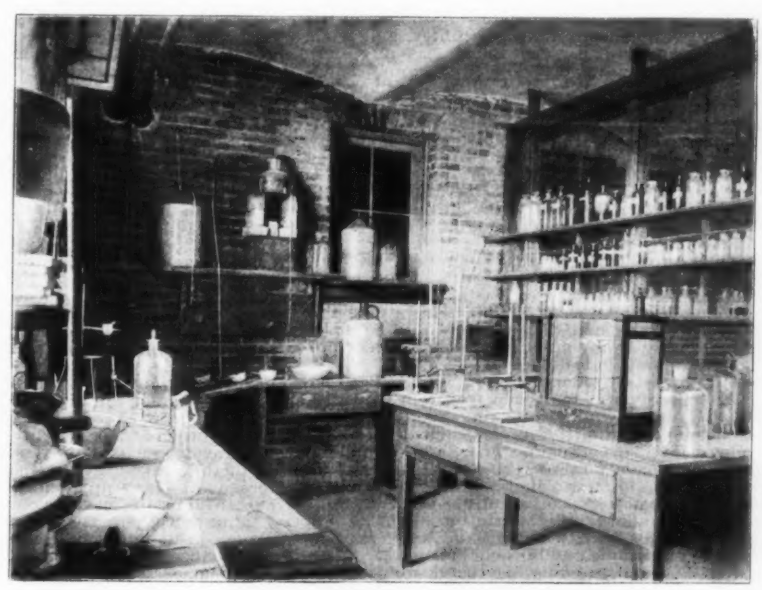
But the paradox is not a real one, for the word ceramics is wofully misconstrued and belittled when it is made to apply only to the artistic side of the fictile art. In a broader and more rational sense, ceramics covers the whole field of clay-work and of the other industries which depend fundamentally on the production and utilization of silicate products, viz., glass and cement manufacture.

ORTON HALL—THE HOME OF THE CERAMIC SCHOOL.

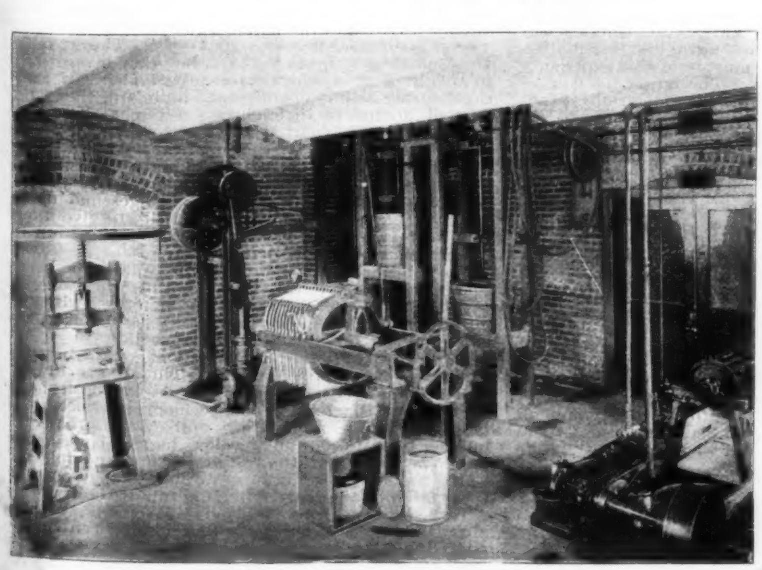
The basis for this statement is found in the fact that in each of these industries the raw materials are common to the others also; that the processes of each overlap in important respects; and lastly that a technical training sufficiently thorough to make its possessor useful in one of the industries would perforce equip him nearly as well for entry into either of the others.

In fact, the application of physics and chemistry to the arts is easily and naturally divided into three great fields. First, metallurgy, or the production of the metals from their ores and their application to the uses of man; second, ceramics, or the production and utilization of the permanent but non-metallic compounds, the silicates; third, chemical engineering, or the manufacture of those countless substances, both organic and inorganic, on which our comfort depends but which are not permanent or durable productions in the sense that it may be said of either iron, or glass, or gold, or porcelain, or stone. Chemical engineering occupies itself with the production of acids, alkalies, colors, dyes, soaps, glues, gelatine, sugar, glucose, ferments, antiseptics, tex-

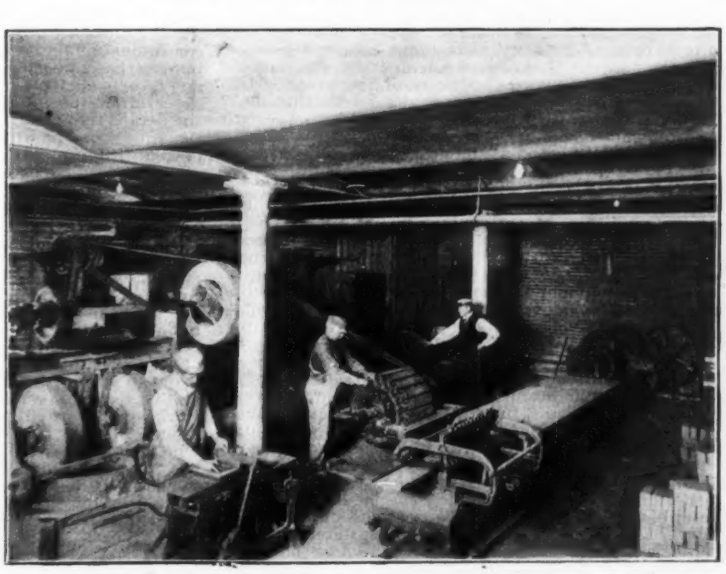
AT WORK WITH THE FILTER PRESS.



THE DIRECTOR'S SANCTUM.



A CORNER IN THE POTTERY LABORATORY.



BRICK-MAKING AND BRICK-TESTING LABORATORY.

tile fabrics such as paper and cloth, and hundreds of others in which chemistry is either fundamental or is used as an important means of supervision and control.

Each of these fields of chemical industry overlaps on the others in numerous points. For instance, the metallurgist depends on the ceramist for the refractory materials in which he smelts his ores and works his metals. The ceramist depends on the manufacturing chemist for his oxides and fluxes, and the chemist in turn on both of the others for every tool of his profession, from his platinum crucible to his glass beakers. But, nevertheless, each is a field of its own, with its own history, its own methods, and its own future, and each requires its own study and exploitation.

From this standpoint, the opening of a school of ceramics is a step much needed industrially and long delayed educationally. The clay, glass, and cement industries are chemical at foundation, yet they have hitherto used the aid of chemical technology to the least possible extent. They stand now where the metallurgical industries of fifty years ago stood. They offer the exhibition, at once pathetic and absurd, of chemical work done by those who do not understand chemistry, and whose operations must perforce follow the dictates of custom and precedent, or else launch out blindly on unknown paths, staking fortunes on the chance of success.

A chemist in a brick yard, pottery, or glass works is still as much of an anomaly as he was in the blast furnace of a generation ago; but the brick works and potteries of another generation will look back with wonder and marvel how it was possible for them to have struggled unaided so long, with help at their very doors for the asking.

The work of the ceramic department of the Ohio State University is therefore briefly defined as follows: To provide such a technical education and a scientific preparation for those who are to work in the silicate industries as has long been provided for those who have followed other lines of engineering activity.

The department is not an absolutely new institution, for it was founded in 1894, by special act of the Legislature of Ohio, and it has pursued its way with constantly growing strength and success for the past five years. Neither is the idea of a school for the ceramic industries new, for in Europe, especially in Germany, there are many important and well-equipped institutions whose sole work is in this field. But a great difference in the plane of the work here and abroad does exist. The foreign schools, while teaching chemistry, physics, and mathematics as an incident of their course, make the manual skill and practical trade knowledge of the pupil the objective of their course. They produce modelers, designers, and plaster workers and brickmakers and china painters, etc., but to engineers, able to design plants, correct faulty manufacture, and organize and equip industries for the varying demands of new markets and new crude materials, they cannot and do not pretend.

The foreign ceramic schools are very similar to the manual training schools in this country, and while they turn out skillful modelers, mouldmakers, designers, painters, decorators, brickmakers, etc., they do not pretend to give anything more than a rudimentary training in applied science and engineering. It has remained for the United States, and for the great clay-working State of Ohio, to be the first to recognize the true position of this work and accord it facilities suited to its importance.

For the execution of this plan the department has been provided with the most thorough and complete equipment of the sort ever brought together. Its facilities comprise the following:

First: A convenient chemical laboratory, in which the student enters only after one year's thorough drill in the regular elementary course in chemistry. He begins here the analysis of simple minerals, passing progressively to the more difficult ones until he is able to analyze correctly any mineral or preparation or product of the ceramic industries.

Second: A pottery laboratory, equipped with a complete mechanical outfit for the preparation of bodies, glazes, and colors, and for making and testing the wares themselves, from the most common red crocks up to hard feldspar porcelain. There are wet and dry ball mills, blungers, power-screens, tanks, and cisterns for bodies in slip form, two filter presses, potter's wheel, potter's jolly, potter's lathe, encaustic tile press, four glaze mills, grinding mill, assortment of molds and models for plaster work, with bins and ample storage receptacles for supplies, and benches for work.

Third: A complete plant for the manufacture of brick, tile and terracotta, and the testing of the wares when made. The machinery here is all full working size, and the products compare favorably with the best. The clay is ground in a five-foot dry pan, equipped with tight dust box, so that each sample, consisting of a large or small quantity, can be kept entirely separate from any other. Then follow a tempering mill, an auger brick machine with assortment of dies to make all ordinary kinds of brick, an automatic cutting machine, a repress with assorted dies, and two paving brick testing machines. The power is furnished by a 15 H. P. electric motor, available at any time from 7 A. M. to 10 P. M. The plant is installed in a new fireproof stone building, modern in every appointment.

Fourth: The kiln house is a separate structure just a few feet distant from the other laboratories. It is a modest little building 14 × 36 feet, containing a down-draught kiln, 6 × 6 feet × 10 feet high, and an up-draught muffle 3×4×8 feet; both are equipped to burn coal or coke, and have stacks 40 feet high. Each kiln is provided with connection to a Chatelier thermo-couple pyrometer, with draught-gage and with automatic gas sampling outfit for analysis of the waste products of combustion. No ceramic kiln has ever been constructed in which such extensive opportunity for investigation on the distribution of heat in the firing process is possible. In addition there is a small gas muffle, a gas frit kiln for making glasses or glazes, and a small crucible gas furnace for high temperature tests. These are supplied with gas from a special carbureter and with blast from a pressure blower. All the saggers, crucibles, retorts, muffles, special shaped bricks and blocks required by the department are made and burned at home. Coal and coke bins, water, gas and electric lights are provided, so that the long hours of watching by the kilns, which ceramic experiments require from pupil and teacher alike, can at least be passed in comfort.

Fifth: The lecture room, museum, and library are located in the same building. This room is provided with glass cases, filled to overflowing, not with samples of rare old china and expensive bric-a-brac, but with broken shards of pottery and deformed bricks, bottles of rare clays, pieces of the impurities found in clays and samples showing their effects on the clay wares; it is anything but the ordinary ceramic museum, yet it admirably fulfills its purpose of showing to the student the troubles and dangers he must face as a ceramist, and how to recognize and avoid them. It is not a beautiful, but a practical, useful collection, with an educational value far greater than any of the superb collections which adorn the museums and galleries at home and abroad. The library represents nearly everything extant which touches on the technology of the silicate industries. Unfortunately, this is not saying much, for the wealth of ceramic literature has so far been lavished on the work of the collector and curio hunter, rather than the chemist and engineer.

Such is the equipment which the University holds out to students who desire to avail themselves of this opportunity. There are two courses, one occupying four years, for which a degree is offered, and the other extending only over two years, with no degree. The work exacted from students is such that anyone of fair ability can accomplish it with diligent application.

As for the results already accomplished, it may be interesting to state that during the five years of work now past, fifty-one students have matriculated in the courses offered by this department, coming from sixteen States of the Union. Of this number, nineteen are now enrolled in the department, seventeen have dropped by the wayside, unable for one reason or another to complete the work, and fifteen have finished the short course of two years' duration, and have gone forth into the world to show the value of their training. Of these fifteen, thirteen are actively at work in various capacities in encaustic tile works, terra cotta and enamel brick plants, roofing tile factories and similar establishments. Several of them have already obtained positions of importance and responsibility in the short time since leaving school.

CAUSES FOR THE ADOPTION OF WATER-TUBE BOILERS IN THE UNITED STATES NAVY.*

By GEORGE W. MELVILLE, Engineer-in-Chief, U. S. N., Vice-President.

IT has been a number of years since I have had the honor and pleasure of addressing this society. Speaking generally, the progress and design of machinery of warships has been, during that time, along such well developed lines, and so in accordance with the generally accepted theories of designers, that there has been little to say. More recently, however, in order to keep pace with the times and to cope with the necessity we have always before us of securing ships that will be in nowise inferior to those built for any other nations, a change in machinery design has been made that at first glance appears radical—the general adoption of water-tube boilers for all new vessels of our navy.

Elsewhere violent diatribes have been launched against those responsible for a similar decision, and I am aware that there exists a not inconsiderable sentiment in this country against water-tube boilers. I call it a sentiment advisedly, because I believe that much of it is due to the attachment that engineers have for their old and proved friend, the cylindrical boiler.

Only a part of the opinions unfavorable to the change arises from the natural and proper conservatism of naval architects and marine engineers, but these demand answer. Flooded always with new devices, or rather by rejuvenated failures in new forms, we find a very small proportion that is even worthy of a trial, and where a new mechanical idea is tried on shipboard, so much time is spent in adapting it to naval conditions and in repairing its failures that each of us becomes naturally and properly dubious when any change is suggested. Any important change in design, even of the apparently minor fittings of ships, may involve such risk to vessel and crew as to be unjustifiable, unless the device be thoroughly tried beforehand. Many apparently good ideas have given successful results on shore only to fail dismally at sea. I think that it may be given as a general rule that no change in design should be authorized that has not already been successfully made.

Of course, a strict application of the foregoing rule would lead to stagnation. Here, however, enters the designer. His role is an important one. He has to cull the good points from previous work, and, if he be a good designer, he must also leave out the bad points. There always are some bad points, but amelioration of conditions should be the aim of naval designers. This implies that a good designer must be of vast experience and of extended observation. The larger his field of observation, the more valuable his conclusions. It is the details that count. No man can succeed as a designer of warships without the most careful attention to small things.

The modern battleship is a monument to the greatness of the minutiæ of design. It has been gradually built up from the sailing beauties of a century ago. Steps in advance have been slow, generally speaking. We cannot advance by leaps and bounds in marine work. Here genius is hampered by such conditions as make any step in advance a great achievement. Of course, we have the case of Ericsson and the "Monitor," but this was a case not only of special conditions but also of a most exceptional man. Naval architecture is a pyramid, each stone of which is supported by all of the preceding ones. The size of the stone that one man can add to the pile depends, of course, upon his ability, but more especially upon his work. By hard work and by paying attention to what is going on around him any man can add his quota, but "those who, having eyes, see not; and who, having ears, hear not," are worse than useless.

The task I have set myself to-day is no mean one. I desire to show that the decision to use nothing but water-tube boilers in our future war vessels is a step in advance, and that it is a natural step toward the evolution of the perfect fighting machine. I desire to show that it is no radical change, and that it does not involve the use of anything but a tried, successful and reliable apparatus that gives us positive and great advantages over the character of boilers heretofore generally used. I desire not to minimize the disadvantages following this change, but to show that these disadvantages are not only not insurmountable, but, for warships, they have already been overcome.

In the first place, I want to state that water-tube boilers are bad in principle. They carry the pressure inside their weakest parts, the tubes. A failure in a tube is followed by the opening of a fault, sometimes to a dangerous degree. In a fire-tubular boiler, on the contrary, the pressure would continue to close a split tube. It is true that a failure of a boiler tube generally comes from pitting, where fire-tubular boilers generally have such a great advantage, as in cases of split tubes. Yet failure of tubes is the most common defect in all boilers, and a proper design would place the pressure on the outside of the tube. Water-tube boilers are, from their very definition, designed from a wrong principle, not only because of the direction of application of pressure upon the tubes, but also on account of the decreased amount of water in the boiler, of the increased difficulty of observing a leak, and of the decreased value of heating surface in water-tube boilers. For this reason, as an engineer, it is with some misgivings that I state that I consider water-tube boilers tactical necessities for warships.

Builders of water-tube boilers use solid-drawn tubes almost exclusively for marine work. This, of course, decreases the danger of split tubes, but it does not change the mechanical principle. Some day, probably not in my time, we may hope to have a boiler having fire tubes and having the advantages of water-tube boilers. Such a boiler would force its way at once into all navies, just as water-tube boilers are doing at the present day.

Disbelieving, as I do, in the cardinal principles of water-tube boilers, I have sturdily opposed their adoption by our navy until now I am convinced that they must be used if we are not going to content ourselves with inferior ships to those built for other nations. Of course, during the period of development of the design of water-tube boilers, that even now continues, I have, in my official capacity, kept track of and taken part in the world-wide experiments with their use. Water-tube boilers have advantages and I have never been blind to them. Two years ago I stated that their disadvantages had been sufficiently removed to justify their use on our warships. Now I consider that the value of their advantages has been sufficiently developed to necessitate their use if we do not wish to be left behind in naval design.

The principal thing to which I desire to call attention is the fact that all vessels are essentially compromises. Any ship must be considered in its entirety, and the advisability of a change in design of any part must be determined from its effect upon the ship as a whole. Whether or not water-tube boilers are superior to cylindrical boilers as boilers simply, if there be a beneficial effect upon the ship as a whole due to the adoption of water-tube boilers, these boilers are essential to the best design.

The necessity of compromise in ship design must be self-evident to the members of this society, who have the problem before them for solution almost daily. Taking the particular case of warships, the size of our ships is limited by their draught. We are building vessels now that are as large as any that can enter our harbors and docks, and we cannot, therefore, increase their power as fighting ships except by improvements in design. Any increase in weight allotted to one essential of the efficiency of the ship must be counterbalanced by a decrease in some other perhaps equally essential element. So far, this has most frequently been done by robbing the coal pile; an extra gun, a half knot in speed, or an additional inch in armor protection—each mean a few tons loss coal in the bunkers. I must except the more recent designs of battleships from the above general rules. The importance of coal endurance has become more and more manifest and it has been appreciated fully in our recent designs. Incidentally, these last ships are fitted with water-tube boilers.

Water-tube boilers are considerably lighter than those of the old type, and their effect upon ship design may be given as follows: Of two ships having all other qualities identical, one fitted with cylindrical boilers and the other with water-tube boilers, the latter will be somewhat the smaller and handier—will have somewhat less draught, and will cost less.

Limited, as we are, in the size of our warships by their draught, I think that the foregoing shows that for a maximum of fighting efficiency we must use water-tube boilers. The designing engineers of our naval vessels are limited in weight and space. They save little or nothing in space perhaps, but they save greatly in weight if they adopt water-tube boilers. If these can be successfully operated on shipboard, they must be used because of their decreased weight. The foregoing is entirely apart from any consideration of the relative merits of water-tube and fire-tubular boilers, but it is conditional upon the possibility of the successful operation of water-tube boilers.

Before considering claimed advantages and disadvantages of water-tube boilers, I desire to give a few historical facts, most of them already well known to the members of this society.

The old Martin boiler was the first water-tube boiler ever used in any naval vessel. We had good success with these boilers, but they died out of use with the introduction of high-pressure multiple-expansion engines and the consequent cylindrical boilers.

For years none but water-tube boilers have been installed in our steam launches. These have always been attended by unskilled labor, yet the results have been very satisfactory. Some accidents have occurred, but they have been very few, probably no greater in number than if fire-tubular boilers had been used, and it is to be noted that the results of a boiler explosion would probably have been worse in almost every case if the failure had occurred in a fire-tubular boiler.

Torpedo boats and destroyers in our navy have always, since the time of the "Cushing," been equipped with water-tube boilers of various types. Small bent tube boilers have generally been used. There

* Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1899.

have been some cases of sad accidents in the fire rooms, generally due to carelessness in manufacture, and particularly in tube setting, but not to defective design. The boilers have proved to be quite as reliable as the extremely light engines of these boats. With the small amount of skilled attention it is possible to give torpedo boats, and considering the character of service demanded of these small craft, I think that no engineer will to-day question that the use of light water-tube boilers, with the higher speeds possible as a result, adds to their efficiency and security. I think even Herr Schichau has come to be of this opinion.

The first large installation of water-tube boilers in our navy was on the "Monterey." Indeed, at the time, this was the largest installation of water-tube boilers in any navy. In this monitor, as you all know, there are four round Ward water-tube boilers, with two cylindrical single-ended fire-tubular boilers. The water tube boilers have been satisfactory. It is worthy of note that there has been very little difficulty experienced in maintaining a steady water level, although the boilers have a very small amount of contained water. Tubes have failed by pitting several times, though never with any danger to the firemen. The water-tube boilers have been twice retubed by the ship's force without laying the ship up at any navy yard. On one occasion, probably with a view to thoroughly testing the water-tube boilers, or to satisfy the unholy desires of some person decrying water-tube boilers, the ship made a voyage of about 8,000 knots, largely under forced draught, and, whenever possible, with all boilers in use. There was no resultant injury to the water-tube boilers, which performed well throughout the trial. The combustion chambers of the cylindrical boilers came out of the trial badly bulged.

The Yarrow boilers of the "Nashville" have operated fairly successfully, though they cannot be said to be completely satisfactory on account of the amount of trouble given by bulging of drums and by leaky tubes.

The first set of copper tubes has been replaced by others of steel to considerable advantage. I believe that the latest designs of this type of boiler provide for the use of slightly curved tubes next the fire. This ought to be advantageous.

The "Marietta's" trip around South America, at the beginning of the war with Spain, was quite as successful as was that of the "Oregon." The first ship is fitted with Babcock & Wilcox boilers, the second with cylindrical boilers. No repairs were required to either set of boilers after the completion of the trip.

The "Annapolis" is also equipped with Babcock & Wilcox boilers, and here, as on the "Marietta," these boilers have been thoroughly successful. Indeed, a former chief engineer of the "Annapolis" has stated to me that the boilers of that ship were easier to manage in use and easier to maintain in a state of high efficiency than are cylindrical boilers.

The "Chicago" has several Babcock & Wilcox boilers, and these have so far worked in a thoroughly satisfactory manner, no failure being reported under any circumstances.

The foregoing represents the tried installations of water-tube boilers in ships larger than torpedo boats and destroyers in the United States navy. Babcock & Wilcox boilers of the shore or stationary type were installed in the old monitors "Canonicus," "Mahopac," and "Manhattan," the old rectangular boilers being entirely worn out and it being deemed advisable to fit these old boats for whatever service they could do. The change was commenced at the beginning of the Spanish war. Before its close the change was complete and a somewhat greater speed was attained than with the original boilers. This change was made without injuring the decks of the monitors. The old boilers were cut up and passed out through the smoke-stack, down which the parts of the new boilers were passed, the latter being assembled in the engine room space. This is an instance where none but water-tube boilers could have been used, and where every facility of repair and installation was of enormous advantage. For naval vessels with their protective decks the facility with which water-tube boilers can be removed or completely renewed without disturbing the decks may, of itself, justify us in adopting water-tube boilers.

There are building and repairing several other ships of our navy to be fitted with partial or complete outfits of water-tube boilers. These include the "Alert," "Atlanta," "Cincinnati," "Wyoming" (Babcock & Wilcox), "Maine" and "Connecticut" (Niclausse), "Missouri," "Wisconsin," and "Arkansas" (Thornycroft), and "Florida" (modified Normand).

The foregoing gives the installation of water-tube boilers in our navy from which data has been obtained. So far as tried the boilers have invariably been easy of operation, though I have found more skill required to obtain the best results from these boilers than would have been necessary if cylindrical boilers had been used. Particular attention has been given in all cases to the feed arrangements. Water-tube boilers must have ample feed pumps, and the regulation of the feed must be easy. At first the heating surface of water-tube boilers was made 3 square feet per horse power against 2 square feet necessary with cylindrical boilers. This figure has been gradually reduced until now we are down to 2·4 square feet of heating surface per horse power, about as low as I think it is yet safe to go with water-tube boilers.

The economical results from water-tube boilers were at first not particularly good. At present we get quite as good results from water-tube boilers of the latest design as from the best cylindrical boilers. The ratio of heating surface to grate surface has been kept up to at least 40, although we do not yet feel warranted in allowing as small grate surfaces in water-tube boilers as in cylindrical boilers. Water-tube boilers lose in efficiency when forced, especially those of the straight-tube type. Of course, this is not of very great moment to us in a naval vessel which is under forced draught only at maximum speed, but it is nevertheless a disadvantage.

The following table shows the relative economy of cylindrical and water-tube boilers.

The increased grate surface we have required with water-tube boilers will be a positive advantage to our ships' steaming qualities. I consider that sustained sea speed depends largely upon the grate surface. Heating surface, of course, must be provided, but I

	Annapolis.	Marietta.	Newport.	Princeton.	Vicksburg.	Wheeling.
Type and number of boilers....	(2 B. & W.)		(2 single-ended cylindrical)			
Displacement, tons	1,000	1,006	1,000	1,000	1,000	1,000
Knots per ton of coal at most economical speed	26·38	22·27	18	19·6	21·25	16·6
Number of screws..............	1	2	1	1	1	2
Grate surface, sq. ft	98	94	78	78	78	69
Heating surface, sq. ft.........	3,620	3,664	2,524	2,524	2,524	2,508

should prefer an excess of grate surface to an exceedingly high ratio of heating surface to grate.

Up to this time we have had no trouble from salt water or grease in water-tube boilers. Indeed, we could hardly be more troubled by salt water with this type of boiler than we have been with cylindrical boilers. We suffered severely in our short war with Spain from dropped furnaces in cylindrical boilers. I do not think that a properly designed water-tube boiler will give more trouble from the use of impure feed water, such as sometimes we must have at sea, than any other boiler. I do not think tubes more more liable than furnaces to fail from a deposit of scale. In any event, the evaporating plants of all our ships are being made adequate to give fresh feed water. The only danger of salt water in the future should come from leaky condensers.

Glancing abroad for a moment, we find every modern naval power, from England to Japan, committed to the use of water-tube boilers on the largest scale. Each of these countries has had its experience, and each has decided not only that water-tube boilers can be worked, but also that they work well and that they must be used in naval vessels.

I will give a few observations on the working of various types of water-tube boilers abroad. The result of a first glance would seem to be that anything would do to make steam, from Watt's tea kettle to the most complicated of modern steam generators. I know of one French boiler (you know what ingenious mechanics the French are) composed equally of water and fire tubes. The tubes were concentric and the distance between them but one millimeter. Of course the amount of water is very small—so small as to put this boiler in the class called by their originators "inexplosible." This boiler was tried at the works of the maker with good results. It was next tried in a torpedo boat with equally remarkable results—7 men killed, I believe.

We have read of explosions, however, of really well-designed water-tube boilers. Generally it is found that a tube had failed and that the furnace door was open—the result, more or less fatal burns to all in the fire-room. We hear of all the failures but the successes are never mentioned. It is not difficult to foresee the failure of a boiler plant designed to furnish 120,000 pounds of steam per hour but regularly required to furnish 160,000 pounds per hour. If nothing else fails, the feed pumps will not do the work and the tubes will, of course, be burnt out. This would happen with any type of boiler.

You see, I harp on the failures, for I find I can glean the most information from them. Many of the failures have come from the use of boilers that were inaccessible for cleaning and repairs; others from faulty design; others from poor workmanship; others, again, from neglect. Water-tube boilers require skilled attendance. Other boilers have failed from poor material; others from failure of the feed pumps; but there is not one, so far as I know, that can properly be said to have failed purely as a result of being a water-tube boiler. Failures may come from misusing water-tube boilers, but not from using them. I consider that the experience of the last ten years or more in our own and in foreign navies justifies me in stating that water-tube boilers, when proper precautions are used, can be successfully adopted for the steam generating plant of ocean-going vessels. They are necessities to the best design of warships.

I would naturally come now to a discussion of the claims of the adherents and opponents of water-tube boilers. You have all heard these arguments and it seems almost useless to go over them. I shall simply state what I believe to be the advantages and disadvantages of water-tube boilers compared with cylindrical boilers.

ADVANTAGES.	DISADVANTAGES.
Less weight of water.	Greater danger from failure of tubes.
Quicker steamers.	Better feed arrangements necessary.
Quicker response to change in amount of steam required.	Greater skill required in management.
Greater freedom of expansion.	Units too small.
Higher cruising speed.	Greater grate surface and heating surface required.
More perfect circulation.	Less reserve in form of water in boiler.
Adaptability to high pressures.	Large number of parts.
Smaller steam pipes and fittings.	Tubes difficult of access.
Greater ease of repair.	Large number of joints.
Greater ease of installation.	More danger of priming.
Greater elasticity of design.	
Less danger from explosion.	

A saving in space has been claimed for water-tube boilers, but I do not find this claim sound when account is taken of the increase in grate and heating surface necessary in water-tube boilers to insure satisfactory working, and because of small units the space for accessibility is increased rather than diminished.

The fact that water-tube boilers raise steam quickly is of the greatest advantage. I have stated elsewhere that I consider the battle of Santiago to have developed the necessity of the use of water-tube boilers whether it taught us anything else or not. It would have been of the greatest advantage to have had, during the blockade of Santiago, boilers capable of raising steam in less than half an hour. Coal need not have been used to keep all the boilers under steam all the time. The "Massachusetts" might have shared in the glories of the fight if she had been fitted with water-tube boilers. The "Indiana" would have kept up with the "Oregon" and the "Texas." The "New York" would have developed at least three knots more speed and the navy would have been spared a controversy. I think the "Colon" would not have gotten as far away as she did. But we did not have the water-tube boilers.

The higher pressures possible with water-tube boilers give us smaller and safer steam pipes and better valves. It decreases the size of the fittings and the difficulty of tracing the labyrinth of a ship's piping. It increases the efficiency of the engines. The introduction of compound engines forced us to use cylindrical boilers. In the same way the use of quadruple expansion engines necessitates, for economy, the use of water-tube boilers.

But the quick steam raiser is, because of that very fact, not so safe as its predecessor. Of course, nothing on a man-of-war is very safe in war time, but we want things as safe as possible, and the boilers are the keys to the situation in the modern battleship. I think that safety in handling water-tube boilers may be assured by using skill in the fire-rooms. I have more than ten years' successful experience with water-tube boilers on which to found this opinion, and I submit that the boilers, placed as they are behind the heaviest armor and below the thick protective deck, are, at the worst, the safest apparatus on a battleship. If we can make them work well, we would do wrong to refuse to use water-tube boilers on our ships.

For merchant and for yacht practice it is a different question. I was recently asked what boilers to use on a large steam yacht. I recommended cylindrical boilers. For merchant work the boilers are always in use developing a fixed power. Weight is not there so important as in warships, and I think it is at best a moot question whether cylindrical boilers are not still the best that can be fitted in ocean-going merchantmen. In some cases where there are short trips and the opportunities for repair must be gotten during the very short lay-ups at the end of the route, the quick steam-raising qualities of water-tube boilers, with their freedom of expansion, enables blowing down the boiler immediately on arrival in port and still having steam at an hour's notice on all boilers. Such cases as this seem to me to demand water-tube boilers.

As to the type of boiler to be used there are as many to choose from as there are fleas on a dog. Some one has said that a certain amount of fleas keep a dog from brooding over being a dog. So the number of varieties we have to choose from may be a good thing for all.

I have always opposed the use of boilers containing screw joints in contact with the fire, and have attempted to secure boilers having no cast metal in the pressure parts. Cast steel is not yet good enough to put between 300 pounds of steam and our firemen. I believe in straight tube boilers as being easier of examination and repair than bent tube boilers. I believe in large tube boilers for the same reason and because the tubes are thicker and have more margin for corrosion. I believe in boilers having as few joints as possible. Water-tube boilers must have freedom of expansion of the various parts, and the simpler the boiler the better. It should not be necessary to introduce reducing valves between the boilers and the engines to secure a steady steam pressure at the latter, nor should it be necessary to have automatic feed arrangements to insure steady water level in the boilers. To be successful a boiler must be easy of repair. Lightness is a natural attribute of all water-tube boilers, but it is not wise to go too far in this direction. The ratio of grate surface to fire surface occupied for the complete boiler plant must be as large as possible. The units should be large, the grates short and not too wide. The passage of gases through the tubes should be sufficiently long to insure economy. These gases should be well mixed before entering the spaces between the tubes for the same reason and to prevent smoke. The circulation of the water in the boiler must be free. Tubes should not be too long and the fire-rooms must always be sufficiently wide to provide for free withdrawal.

The foregoing is what we want. We have most of the above desiderata in several well-known types of boilers, and ultimately we shall discover the value of each of the foregoing points, and then it will be possible to differentiate between the various types more perfectly than we now can.

In the meantime, all that I have to say is that the use of water-tube boilers has been definitely decided upon for our naval vessels, because water-tube boilers give tactical advantages of great moment, and because, with care in the selection, manufacture and management of water-tube boilers, other disadvantages may be neutralized.

THE WORLD'S LARGEST BLAST FURNACE COMPANIES.

SOME of our readers may be interested in comparing the largest blast furnaces in this country and in Europe says The American Exporter. The Austrian Alpine Montan Gesellschaft is said to be the largest single owner of blast furnaces in the world. This concern owns thirty-two furnaces, although most of these are of small size and run on charcoal iron. William Baird & Company, of Glasgow, have twenty-nine furnaces with a total capacity of about 400,000 tons. The Middlesborough concern of Bolckow, Vaughan & Company owns twenty-four furnaces with a total of 750,000 tons capacity, and two other British companies, the Dolway Company and the Barrow Company, own fourteen plants with an annual capacity of about 250,000 tons each. In the Lorraine region the De Wenkels own eighteen furnaces with a combined capacity of about 730,000 tons.

In the United States the leading concerns, with the number of their blast furnaces and their producing capacity, in tons, are as follows:

	Furnaces.	Capacity.
Carnegie Steel Company	17	2,200,000
Federal Steel Company...........	19	1,900,000
Tennessee Coal and Iron Company..	20	1,307,000
National Steel Company...........	12	1,205,000
Virginia Iron, Coal and Coke Company..................	12	566,000
Cambria Iron and Steel Company...	6	480,000
Lackawanna Iron and Steel Company..................	9	440,000
American Steel and Wire Company.	5	385,000
Maryland Steel Company..........	4	358,000
Republic Iron and Steel Company..	5	325,000
Empire Iron and Steel Company....	10	319,000
Pennsylvania Steel Company.......	5	300,000
Sloss Iron and Steel Company.......	4	225,000
Colorado Fuel and Iron Company...	3	200,000

The combined annual capacity of the Carnegie Steel Company, the Federal Steel Company, the Tennessee Coal, Iron and Railroad Company and the National Steel Company, the four largest establishments, is 6,712,000 tons, considerably more than half of

the total production of pig iron in 1898. The actual production of these four companies for 1899 will probably be one-half of the total production, so that it may be said that four companies control 50 per cent. of the iron made in the United States.

THE MODERN ARMOR-CLAD.

THE armor-clad ship of war is of relatively modern creation, and made its first appearance in France. The three protected floating batteries constructed in 1854 for the Crimean war, and which Russian balls were powerless to penetrate, constituted the embryo of armor-clad fleets.

A few attempts at armor plating ships had previously been made, but they were crude and imperfect. The frigate "La Gloire," constructed in 1859-1860, was the first ship that was provided with armor plating of any importance. This was of iron, and 4½ inches in thickness.

During the following year, there were constructed, after plans by Dupuy de Lome, some ships that were provided with an armor of 6½ inches. Then, shortly afterward, the "Ocean," "Marengo," "Friedland," and "Suffren" were set afloat with armor plating of 8 inches. The example set by France was soon followed by foreign navies, especially by the English navy.

The first iron armor plates were formed of sheets riveted together in order to obtain the desired thickness, or else were forged by means of the steam hammer. Those made by the first process offered less resistance to projectiles, and those made by the second became difficult to manufacture when the necessity arose of assembling several of the hammered plates on the anvil. They could not be shaped mathematically nor be made to fit each other with sufficient accuracy and precision. The experiment was then tried of interposing between them a mattress of wood, which permitted of uniting them better, and which, in addition, reduced the vibrations produced in the mass and transmitted to the assembling bolts. The progress of artillery, and especially the use of steel or hardened cast iron shells, soon rendered such plates vulnerable. Then their thickness was increased, and steel was subsequently substituted for iron; but a new inconvenience presented itself, the steel broke under the impact of the shell. It was not until some time afterward that manufactories succeeded in producing a hard non-frangible steel.

In the meanwhile, the industry was making progress. In 1869 manufactories in England succeeded, through rolling, in obtaining iron plates 8½ inches in thickness that resisted the projectiles of a 2¾ inch gun.

Up to 1877 armor plate was made (1) of forged iron, (2) of steel, (3) of forged iron alternating with wood, and (4) of soft iron alternating with plates of cast iron.

In the same year appeared the compound armor plate. This was manufactured at Sheffield by pouring molten steel over a plate of iron heated to redness, and rolling the whole to the desired thickness, or else by pouring molten steel between two plates of iron and steel so as to weld one to the other. Such plates were 15 or 20 per cent. stronger than any of the preceding ones, even those very renowned soft steel ones of Creusot, and were not brittle. At the epoch mentioned, they were employed to the exclusion of all others.

In 1881 the Creusot works produced a variety of steel and nickel-steel (the Schneider metal) which offered a better resistance than the compound metal. After some trials that demonstrated its superiority, Italy adopted it for the protection of her large armorclads. But Harveyized steel, that is to say, steel hardened by the Harvey process, now came to dethrone it. This process consists in a superficial hardening brought about by a progressive cementation by means of which there is given to the plate a proportion of carbon that decreases regularly from the surface to a certain depth in the mass. A steel plate is laid flat upon a bed of sand in a sort of box of refractory bricks installed upon the dead plate of a furnace. The plate is enveloped laterally by the sand and is covered with case-hardening carbon or carbureted materials that are carefully packed. Upon this is placed a bed of sand and a layer of refractory bricks, which compress the bed of carbon. The furnace is heated to about 1,000 degrees, and this temperature is kept up so much the longer in proportion as a deeper and more pronounced carburation is desired. The preliminary heating of the furnace requires forty-eight hours, and the temperature is generally maintained for twenty. After the fire has been allowed to fall, an interval of four or five hours is permitted to elapse before the plate is taken out. During this time it has cooled down to a dark red. Water in the form of a very fine spray is then thrown continuously upon the plate for four or five hours so as to temper the case-hardened part by cooling, and also to prevent it from reheating through the abstraction of caloric from the rest of the plate before it has become thoroughly cool.

Steel that has been submitted to such a treatment acquires a hardness such that it is no longer possible to drill holes in it without first destroying its temper. The holes necessary for bolting the plates to the hull of a vessel are made previous to the Harveyizing. The quality of the plates is greatly improved by adding some nickel to the steel.

In the United States nothing is now used but nickelized steel, and the case-hardening carbon has been replaced by hydrocarbides, such as acetylene, illuminating gas, and the vapor of petroleum. After carburation, the plates are submitted to a very powerful and uniform compression and are forged beneath in order to give them the desired thickness. This forging hardens the metal, diminishes its tendency to break and restores to it the fine grain that it had lost through the crystallization caused by the high temperature developed during the carburation. Besides, it stops up the holes and fissures and suppresses the bubbles that, originally very small, might have increased in size. In this way there is obtained a final product that is hard, strong, and solid.

It sometimes happens that the ordinary Harveyized plates fissure under the impact of projectiles; but an improvement in the process made at the Krupp works gives perfect plates that will not fissure. This process is exploited at Saint-Chamond.

A Krupp plate 12 inches in thickness has received an 11-inch steel shell weighing 515 pounds and two 8-inch shells weighing 308 pounds, and another and similar plate has received three 12-inch shells weighing 724 pounds without the hardened surface of any of them exhibiting anything more than a few slight indentations.

After such victories of armor plate over the gun, it might be thought that the triumph of the former was final. But such is not the case. Owing to the progress made in the manufacture of projectiles, the advantage has again passed to the latter. A Harveyized steel plate 6 inches in thickness has received two 6-inch shells without either of the two being able to penetrate it to a depth of more than 2¼ inches. Two Hadfield projectiles of the same caliber, having an initial velocity of but 1,885 feet, traversed it. However, it may be said that at sea, where firing is not done under as favorable conditions as it is on proving grounds, a plate of Harveyized steel 17 inches in thickness is impenetrable to projectiles of the largest caliber.

The plates of "La Gloire" were 4¼ inches in thickness and weighed 2,200 pounds. The weight of the armor plate, in proportion to the total weight of the ship, was 15 per cent. Compound plates have been manufactured of a thickness of 22 inches and of a weight of 40 tons. The weight of the armor plate then reaches 33 per cent. The plates of Harveyized steel, of which the resistance to penetration is double that of forged iron, are not so thick. The thickest are from 16 to 17 inches.

The armoring of the belt is always lined with a mattress of teak, a wood that has the advantage of being imputrescible and not attackable by iron.

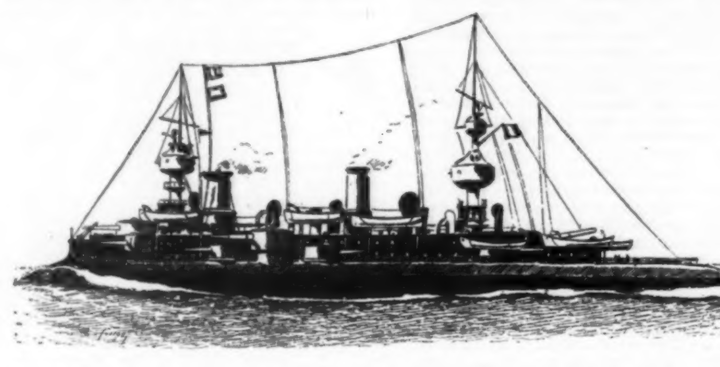


FIG. 1.—FRENCH ARMOR-CLAD "LE MASSENA," OF 11,000 TONS DISPLACEMENT.

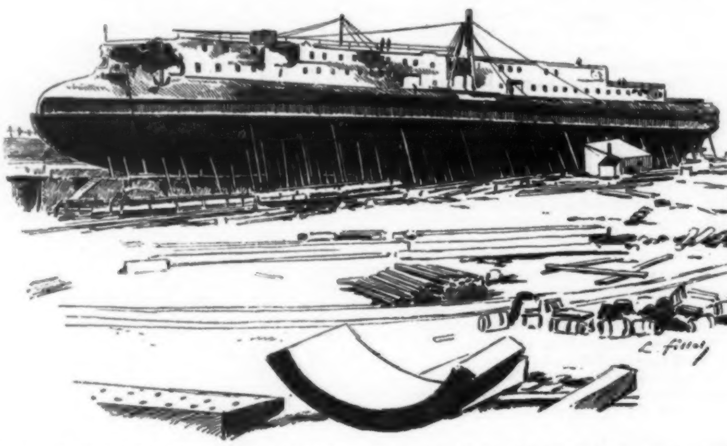


FIG. 2.—FIRST-CLASS ARMOR-CLAD. FORM AND PLATES OF THE ARMORING.

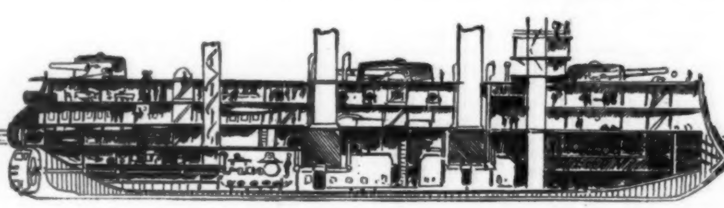


FIG. 3.—LONGITUDINAL SECTION OF AN ARMOR-CLAD.

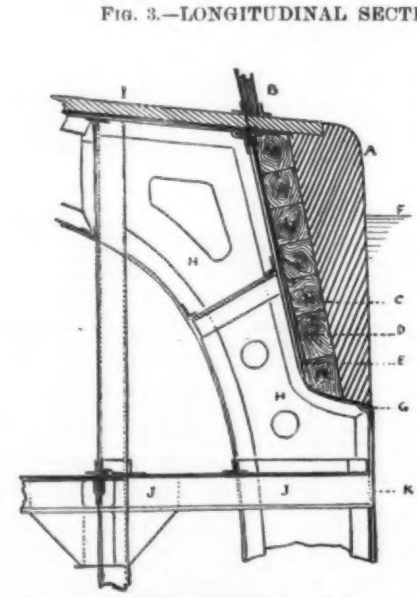


FIG. 4.—FRAME UNDER ARMOR, SUCH AS USED IN FRANCE.

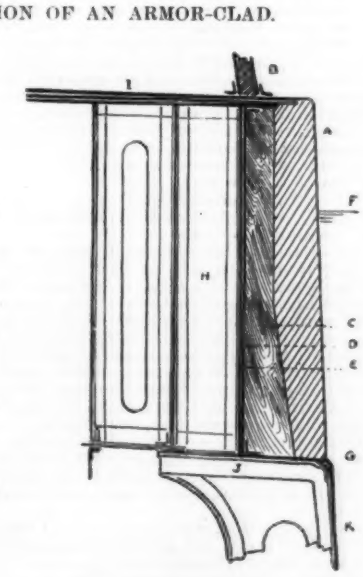


FIG. 5.—FRAME UNDER ARMOR, SUCH AS USED IN ENGLAND.

A. Heavy armor. B. Thin armor above the heavy, almost entirely covering the sides. C. Teak mattress under the armor. D. First backing plate. E. Second backing plate. F. Water line. G. Shelf for reception of the armor. H. Frame of the ship. I. Armored deck. J. Lower deck. K. Hull.

The armor plate and mattress rest upon a shelf in the hull. A double and very strong backing formed of two half-inch plates serves for attaching the armor plate, and prevents splinters of wood from being thrown into the interior when a projectile perforates the armor. The whole is sustained by a strong framework (Figs. 4 and 5).

The mattress is held in place by strong bolts with a flat head sunk in the [illegible] the threaded extremity

of which is screwed into the metal backing or is held by a nut. It is designed to deaden the vibrations caused by the impact of the projectile and to facilitate the putting of the plates in place. Since, under feeble incidences, the mattress is more prejudicial than useful, it has been done away with for the deck, turrets, and conning tower. It has been done away with likewise under the light armor plate of the upper works. It is employed only for the armor plating of the belt.

For holding the plates, set bolts that enter the plate to but a slight depth are employed, and not bolts that pass entirely through, since every hole for the latter would create a weak point capable of giving rise to radiating cracks. The hold upon the double backing is obtained through a nut screwed up in the interior. Between the nut and the backing is interposed a rubber washer which deadens shocks and prevents the breakage of the bolt and the projection of the nut into the interior (Fig. 6).

The invariability of the lines of the hull is assured by a carcass composed of transverse frames and longitudinal pieces called ribbands, and consisting of a strong assemblage of iron plates and angle irons.

The frames are united and held at their lower part by a piece called the keel and by a central ribband called a carling. It is to the frames and ribbands that the sheathing is applied. In order to prevent the frames from being distorted by external pressure, their spacing is kept invariable by beams, or metallic trusses that are sensibly rectilinear and that unite the two branches and serve as a support for the decks (Figs. 7 and 8).

The first armored warships were entirely protected and the plates were necessarily of slight thickness; but the progress of artillery obliged builders to increase such thickness progressively. Its weight then became enormous, and there came a time when, in order that a ship might preserve its navigability, it became necessary to diminish to a great degree the surface occupied by the armor. This was preserved only at the load water line, where a ball of the enemy, on piercing the hull, might create a leak and cause the vessel to sink. It was likewise preserved for the protection of the artillery.

But this was not all. The armored belt did not extend all the way around the ship, but covered only the center for two-thirds, a half, and sometimes but a third of the length of the ship. The front and rear remained naked, and consequently exposed to projectiles. An armored deck, it is true, extended all along the vessel beneath the water line and protected it up to a certain point against leaks that might sink it. It was thus possible to economize in weight, and advantage was taken of this to protect the artillery more effectually. This is the system that has prevailed in England; and nearly all of the armor-clads of that country are but

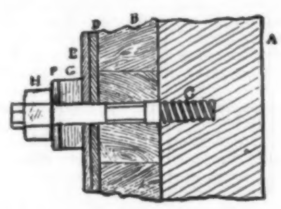


FIG. 6.—METHOD OF ATTACHING THE ARMOR PLATES.

A. Armor plate. *B.* Mattress under the armor. *C.* Set-bolt screwed into the armor. *D.* Backing plate. *E.* External plate. *F.* Iron washer. *G.* Rubber washer for deadening vibrations and preventing the breakage of the bolt. *H.* Nut.

partially belted. But Italy seems to desire to abandon it, since she is providing her two new cruisers, the "Carlo Alberto" and the "Emanuele Filiberto," with a continuous belt. Russia and Germany, on the contrary, which had adopted the continuous belt for all their ships, have just abandoned it and are providing their new armor-clads with a partial belt.

In France, it is the system of continuous belt that has prevailed. It is estimated that the stability of the ship and the liberty of its motions would be too greatly jeopardized by the opening of a breach in front. The French naval engineers have indeed conceived some very decided ideas upon this point, especially since projectiles of great explosive capacity have come into use; and the armoring of the front of the new French ships will not be diminished (Fig. 9).

The English, who have remarked this fact, have become alarmed at it up to a certain point, and have taken it into consideration. Their new armor-clads of the "Majestic" type have received upon their unprotected extremities a surface of wood 11¾ feet in height and 9 inches in thickness. Upon the five armor-clads of the "Canopus" type, under construction, this protection of wood, which permits of stopping only the smallest projectiles, will be covered with plates of nickel-steel 2 inches in thickness.

Of the two systems of armor plating under consideration, the English system of partial belting and the French one of continuous belting, a single war will be able to indicate which is the better.

We have said above that by reason of the great thickness given the armor it became necessary to restrict it to the water line and the artillery, the greater part of the hull remaining unprotected. The invention of rapid-fire guns of large caliber and of projectiles of great explosive capacity has made a revolution in this method of armoring.

Now that a projectile of medium caliber is capable of sweeping an entire battery, of knocking over a turret, and of opening breaches in the side and rendering a ship uninhabitable, it has become necessary to think of fully protecting the entire hull, even in sacrificing a little of the protection to the water line. If it is possible to put his artillery out of action, there will be nothing to be feared from an enemy who no longer has anything at his disposal but a damaged ram; and it becomes useless to try to open a breach in his water line in order to sink him, a result, moreover, that it is difficult to attain.

In the construction of the most modern armor-clads, all the efforts of engineers have therefore been directed toward the protection of the upper works against the effects of rapid-fire artillery and projectiles charged with powerful explosives, in order to render the ship inhabitable under fire and prevent dismantlement.

As the weight of the armor-clad cannot exceed certain limits, the protected surface has been increased only to the detriment of the thickness. It is true that the progress of metallurgy assures modern armor-clads a greater resistance to the penetration of projectiles, but it does not compensate for the diminution in thickness when the latter is very great. Thus, the new English and Italian types ("Majestic," "Canopus," and "Emanuele Filiberto") possess armoring of a resistance slightly inferior to that of less recent types. In France, the thickness of armor has diminished only in proportion to the increase of resistance. The total resistance has not changed.

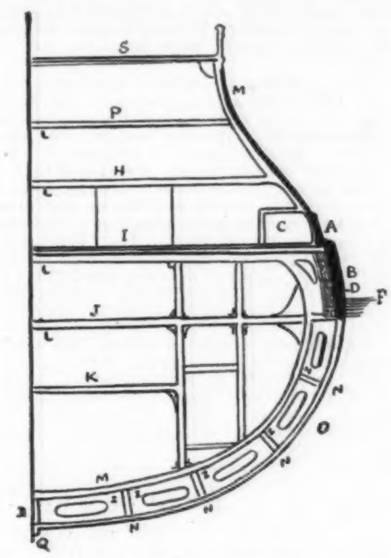


FIG. 7.—SECTION OF AN ARMOR-CLAD WITH A HORIZONTAL ARMORED DECK.

A. Thin armor above the thick armor. *B.* Thick armor. *C.* Cellular partitions. *D.* Framework under armor. *F.* Water line. *H.* Intermediate deck. *I.* Armored main deck. *K.* Platform of the hold. *L.* Deck beams. *M.* Internal hull. *N.* Ribbands. O. External hull. *P.* Quarter deck. *Q.* Keel. *R.* Carling. *S.* Spar deck. *Z.* Transverse frame extending from the keel to the belt.

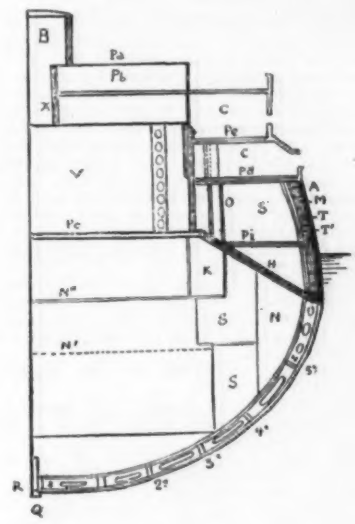


FIG. 8.—PROJECTION UPON THE TRANSVERSE PLAN OF AN ARMOR-CLAD.

A. Armor of the belt. *M.* Mattress under the armor. *T.* Sheathing plate. *T'.* External hull. *F.* Water line. *Q.* Keel. *R.* Carling. *Z.* Frame. *S.* Coal bunkers. *N'.* Level of the platform. *N''.* Level of the lower deck. *Pe, Pi.* Central armored deck. *H.* Slope of the armored deck. *V.* Armored citadel. *Pd.* Main deck. *C.* Casemate. *Pe.* Upper deck. *Pb.* Spar deck. *Pa.* Bridge. *B.* Conning tower. *X.* Armored tube for transmitting orders.

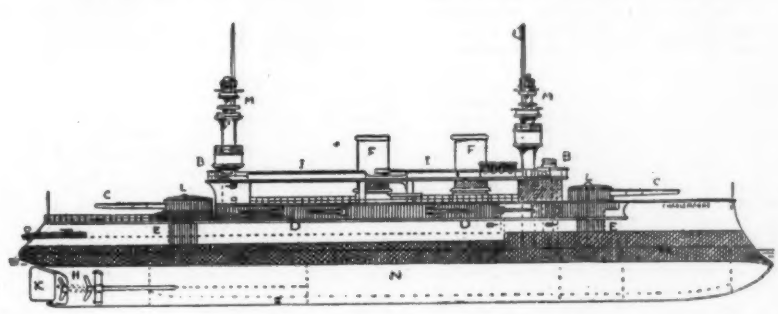


FIG. 9.—"LE CHARLEMAGNE"—A FIRST-CLASS FRENCH ARMOR-CLAD.

A. Continuous armored belt of hardened steel, 16 inches thick in the center and progressively diminishing toward the upper and lower edges, where it is 10 inches in thickness. At the extreme front and extreme rear the thickness is likewise reduced to 8 and 4 inches. It rises to 5 feet above the water line. Above the belt, and for a height of 37 inches, the hull is protected with plates of steel of 3 inches thickness. The protection of the upper works is completed by two horizontal decks of thick steel of 3½ and 1¼ inches thickness. *B.* Conning tower. *C.* Large guns in turrets. *D.* Armor of citadel. *E.* Armor protecting the base of the turrets and the ammunition hoists. *H.* Screw. *I.* Bridge. *K.* Rudder. *L.* Turrets of hardened steel, 16 inches thick. *M.* Military masts with armored fighting tops. *N.* Hold. *Z.* Double bottom.

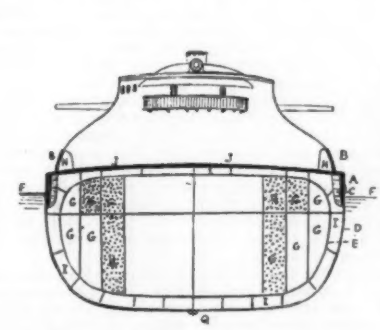


FIG. 10.—ARMORED SHIP WITH HORIZONTAL PROTECTIVE DECK.

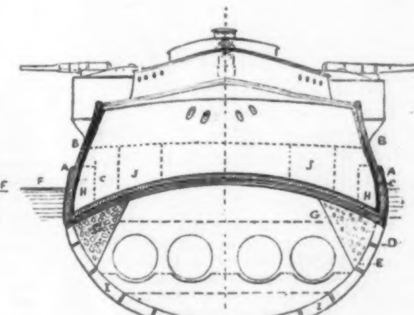


FIG. 11.—ARMORED SHIP WITH TURTLE-BACK ARMORED DECK.

A. Thick armor. *B.* Thin armor above the thick. *C.* Mattress under the armor. *D.* External hull. *E.* Internal hull. *F.* Water line. *G.* Coal bunkers and tight compartments. *I.* Partitions between the two hulls. *J.* Armored deck. *H.* Cellular compartments. Q. Keel.

While the armor resistance was diminishing or remaining stationary, the power of the artillery was increasing to the point of greatly diminishing the calibers for piercing a given thickness.

Like the vertical wall of steel, the armored deck participates in the protection of the armor-clad, although to a less degree. It is of steel and from 2¾ to 4 inches in thickness. Upon ships of war with a continuous belt, it ends at the upper edge of the armor (Figs. 7 and 10), and, when the belt is partial, it joins the upper edge of the citadel for the entire length of the latter. Beyond, it passes to the lower edge and then extends under water as far as to the extremities. Sometimes, instead of being horizontal, it is turtle-backed, that is to say, it curves downward and joins the lower edge of the armor beneath the water line. It thus participates in the protection of the sides and reinforces the latter's armor, which may then possess less thickness (Figs. 8 and 11). Thus, the thickness of the wall of the "Majestic," one of the finest of modern English armor-clads, is only 9 inches, and that of the "Canopus," more modern still, is 6. But the decks of these, as above stated, curve downward, so that, in order to give the ships a mortal wound, the projectile would have to pierce not only the 9 or 6 inches of the armor plate of the sides, but also the 4 inches of steel of a deck inclined at a considerable angle, equivalent, from the viewpoint of penetration, to 8 inches of vertical armor plate.

The armored deck serves to protect the vital organs of the ship, such as the engines, boilers, and ammunition chambers, against the fragments of the projectiles capable of bursting above it. To provide against accidents in case it should be pierced or rent, it is lined with a protective ceiling to arrest the fragments pro-

jected into the interior, or with a second armored deck that extends beneath the water line and is connected with the lower edge of the armor plate.

The protection of the ship against submersion is assured by its partitioning, that is to say, its division into tight compartments that enable it to float in case of damage to the hull. These chambers are used in most cases as coal bunkers. Their number varies according to the size and system of construction of the ship. Certain vessels are provided with two or three hundred of them.

In the "cofferdam" system, the chambers are smaller, and were formerly filled with such materials as cork, compressed cellulose of maize, cocoanut fiber, etc., in order to prevent the entrance of water. They are placed at the water line.

The water line and the region above it have so much the more need of protection by a cellular partitioning in proportion as the armor is more vulnerable. The partitions always rest upon the protective deck, and the "cofferdam" at the lower edges is double or triple and rises to about 4 feet above the water line. It serves for arresting the water that might enter through a breach in the sides, and protects the hull against the blows of the ram and the torpedo. The object of the cellular section beneath, or the double bottom, is to prevent the entrance of water into the hold in case of running aground. The cellular section above, established between the protective deck and the deck beneath it, serves for arresting the entrance of water that might pass through a vent in the deck.

Thus the part of the ship situated below the protective deck may be considered as a long chest inclosing all the vital organs and surrounded at the top, bottom, and sides by four systems of cellular spaces designed to prevent entrances of water.

The collision partition forward and the partition aft complete the protective envelope.

A ship with cofferdam, which forms a triple hull for it, would resist a torpedo charged with from 44 to 55 pounds of a powerful explosive.

All armor-clads have a double bottom or else a double hull. In case of foundering, if the first hull is stove in, the second generally resists and allows the ship to preserve its floatability. Between the external and internal hulls, there is a space which is divided into a large number of small tight cells, which add still further to the protection assured by the internal partitioning of the ship (Figs. 7, 8, 10, and 11).

All the doors of communication of the coal bunkers, compartments, chambers, cabins, etc., all the hatchways and all the openings formed in the main deck are so arranged that they can be hermetically closed at the moment of battle or when an entrance of water is anticipated. Besides, all the hatchways or openings in the deck are surrounded by iron plates from 30 to 36 inches in height. In a word, everything is arranged in such a way that the least quantity of water possible shall find its way into the interior of the ship, no matter how serious be the wounds that it may receive during the course of a battle. If, despite the precautions taken, the water should find an entrance, an extensive system of drainage would lead it to a point of the hold where a powerful pump would suck it up and throw it overboard.

Finally, in addition to the cellular section beneath the armored deck, there exist throughout the entire extent of the latter transverse partitions, tight at the base, for assuring longitudinal stability. If, in fact, the vessel should ship a large quantity of water on deck, even above the water line, such water might, through the pitching motion, run all along the deck or accumulate aft, increase the rolling, cause dangerous changes in the stability and trim, and endanger the safety of the ship. Thanks to the partitions, any water that might enter through a breach would be localized. One or two longitudinal divisions complete this partitioning of the deck. In this immense iron chest, which is almost hermetically closed, the seven or eight hundred men that compose its crew could not live did not a mechanical aeration exist. Powerful ventilators send pure air into every part of the ship and expel the air that has become foul. These ventilators serve also for producing, in the furnaces, a forced draught that increases the speed of the vessel by about a knot. But the forced draught, which burns the boiler tubes, is gradually being abandoned for the natural draught, to obtain which, under the best conditions, modern armor-clads are provided with very tall smokestacks. Wells having their openings upon the main deck are formed at certain places in the ship. These, in case of danger, assure the escape of the men shut up in the interior.—Le Monde Moderne.

(To be continued.)

DESIGNS FOR THE "DENVER" CLASS, SHEATHED PROTECTED CRUISERS.

By Chief Constructor PHILIP HICHBORN, U. S. N., Vice-President.*

HAVING been invited to contribute the usual paper covering designs prepared during the past year, I take pleasure in laying before the Society a brief description of the sheathed protected cruisers provided for in the last appropriations for increase of the navy, together with the general plans, a statement of the general characteristics, weights, etc.

The act of Congress approved March 3, 1899, provided for three sheathed sea-going battleships of about 13,500 tons trial displacement, at a cost for hull and machinery not to exceed $3,600,000 each; for three sheathed armored cruisers of about 12,000 tons trial displacement, at a cost for hull and machinery not to exceed $4,000,000 each; and for "six protected cruisers of about 5,500 tons trial displacement, to be sheathed and coppered, and to have the highest speed compatible with good cruising qualities, great radius of action, and to carry the most powerful ordnance suited to vessels of their class, and to cost, exclusive of armament, not exceeding $1,141,800 each."

The act further provided that "in no case shall a contract be made for the construction of the hull of any vessel authorized by this act until a contract has been made for the armor of such vessel." The limiting price for the armor of these vessels was fixed by the same act at $300 per ton, and the effort to make contracts within this limit was unsuccessful. The designs for the battleships and armored cruisers have proceeded slowly on this account, and will not be submitted for the Navy Department's action for some time to come. I am unable, therefore, to present these designs for this year's proceedings.

The question of armor not being involved in the case of the smaller cruisers, the designs for these vessels were completed and bids invited for their construction under the usual conditions, allowing bidders to submit proposals on the plans and specifications issued by the department, or on their own plans and specifications, based upon certain requirements outlined in the department's circular issued about August 1 for the information of shipbuilders. At the time of preparing this paper, plans and specifications are being sent out to such responsible bidders as have requested them—November 1 having been set as the date for opening bids.

The chief characteristics of the design for these cruisers were settled and approved by the department before the final preparation of the general plans. These characteristics show the vessels to be about the size of the "Raleigh" and "Cincinnati," which, though classed as 19-knot vessels, with more than double the horse power of the present designs, have never been able, owing to certain well-known conditions, to maintain a speed even approximating to the rated 19 knots for any length of time. The "Raleigh," when with Dewey's squadron, was only able to steam, with difficulty, at a speed of 9 knots, using three-fifths of the boiler power. The coal supply of these vessels was also limited, and the coal consumption was a serious question when making passage between distant ports.

In the new designs a liberal allowance has been assigned to all the principal weights, and there has been no attempt to secure "fancy" results either on paper or on trial. They have been designed for hard service, and the offensive and defensive properties, suitable speed, durability, habitability etc., were carefully considered in determining their characteristics. Owing to the nature of the service which they were likely to perform, independence of coaling and repair stations, as far as possible, was believed to be an important consideration.

In view of the fact that the vessels were to be sheathed and coppered, and that the machinery was to be liberally proportioned, a speed of 16½ knots, as representing the capacity of the vessel at all times, was considered sufficient, and easily places the ships in the class with our earlier vessels making 19 or 20 knots on a forced trial with clean bottoms.

The coal supply is represented by a bunker capacity of 700 tons: sufficient to give them a radius of action at full speed of nearly 2,500 knots, and at the most economical rate of steaming—probably in the neighborhood of 10 knots per hour—they will be able to steam about 7,000 knots without recoaling. This would cover a continuous trip from San Francisco to Manila.

Careful consideration has been given to the strength of the vessels, and the scantlings are unusually heavy. The frames are spaced 36 inches throughout the length of the vessel. The inner bottom will be 204 feet in length, divided into 29 compartments. Between the inner bottom and the protective deck there will be 67 water-tight compartments and above the protected deck 39, making a total of 135 compartments in the vessel. They will have three complete steel decks. There will be three longitudinals on each side of the water-tight 34-inch vertical keel, in addition to the bilge stringer and side stringer. The protective deck will be water-tight and ½ inch in thickness throughout. In addition there will be 2 inches of nickel steel 8 feet in width on each slope, for a length of 105 feet in the wake of the machinery. Forward and abaft this on the slope the ½-inch plating will be doubled.

The ram bow has been entirely omitted, it being considered unnecessary for this class of vessel.

Being sheathed, the stem, stern-posts, shaft-struts, and rudder will be of manganese bronze.

The wood sheathing will be of Georgia pine, fitted in a single thickness of 4 inches, secured by composition bolts tapped through the plating, and with nut and washer on the inside. The copper sheathing will be of 28 to 32-ounce material.

Over the protective deck and along the water-line a coffer-dam 27 inches in width and about 4 feet in depth will be fitted; the top of the coffer-dam being about 2½ feet above the normal or 15-foot 9-inch water-line. Fire-proofed corn-pith cellulose will be used as obturating material. This will be packed to a density of 8 pounds per cubic foot, the total capacity of the coffer-dam at this rate being about 24 tons.

The main deck will be the only one planked with wood, and this wood, together with all other wood used in the construction of the vessel, except outside sheathing and that used for special purposes, such as electric wire mouldings, will be treated with an approved fire-proofing process before being worked into the ship. Careful attention has been given to reducing the amount of woodwork in the ship to the minimum. Stateroom bulkheads and the like will be of corrugated metal.

As previously stated, a liberal allowance has been made for machinery weights, the engine-room weights per indicated horse power being about 10 per cent. heavier than is the case with the "Raleigh" or "Detroit" classes. The total machinery weight is somewhat reduced, proportionately, by the use of water-tube boilers and high pressures.

The ventilation of machinery spaces will be thorough, and not subject to the criticism to which the "Raleigh" and "Cincinnati" were exposed.

The armament of each of the vessels will consist of a main battery of ten 5-inch guns of 50 calibers length, and a secondary battery of eight 6-pounders, two 1-pounders, four Colt's automatic guns, and one 3-inch field gun. Eight of the 5-inch guns will be mounted on the gun deck in recessed ports; the forward pair having a range from directly forward to 60° abaft the beam, and the second pair from 83° forward to 60° abaft the beam, the four after guns being similarly placed as regards stern fire. The two remaining 5-inch guns will be mounted behind shields on the main deck, one forward and one aft. Four 6-pounders will be mounted on the gun deck, two forward and two about amidships, and the other four 6-pounders will be located on the main deck. The two 1 pounder guns will be mounted aft on the gun deck, and the Colt machine guns on top of the hammock berthing amidships.

The plating around the gun ports of the gun-deck battery will be thickened up with nickel steel to 1¾ inches. The shields of the 5-inch guns on the main deck will be of 2-inch nickel steel.

The ammunition supply will be unusually large, and will include 250 rounds for each of the 5-inch guns, and 500 rounds for each of the 6-pounders. The use of smokeless powder is contemplated for all ammunition, and special appliances will be fitted for keeping the temperature of the magazines to a minimum. The nature of these appliances will depend somewhat on the results of experience with the battleships now building.

Each vessel will be fitted with a distilling plant, ice machine, refrigerating rooms, electric ammunition hoists, winches and blowers, two search-lights, electrical signaling and other outfits. Storerooms for various purposes will be ample and commodious.

The electric generating plant will consist of 4 units, each with a rated output of 300 amperes at 80 volts.

The complete deck over the battery adds greatly to the efficiency of the design. The complement of crew assigned to each vessel is 263, including 27 marines. These can be readily accommodated. In fact, 450 men could be berthed without discomfort, and the vessels can, therefore, be used to advantage in transporting relief crews to foreign stations, or for other similar service.

Dimensions and particulars of the design, including weights and other data, including machinery, are given in an appendix to the paper, and plates are appended showing the general arrangement of the vessels.

So much has been published about the cruisers built for the Brazilian government, and purchased by us just prior to the outbreak of hostilities with Spain, that I cannot refrain from presenting a few facts—principally because the published statements have been used for the purpose of making unfavorable comparisons with our new designs. One of these publications, for instance, in a prominent scientific paper contained cuts of the vessels, with certain particulars headed, respectively, "The 3,500-ton protected cruiser New Orleans" and "The proposed 3,500 ton semi-protected cruiser 'Denver' and class." It takes but a glance to discover the first gross error in this comparison, for those familiar with the facts—the "New Orleans" having left the New York yard a short time ago, in ordinary full load condition, displacing over 4,000 tons. Under exactly similar conditions, the "Denver" and class will displace only 3,500 tons, and at this displacement the actual weight of ammunition carried and the actual weight of stores aboard will be greater than in the case of the "New Orleans" at 4,000 tons. Moreover, the coal will be practically the same, for the "Denver" will stow and carry 700 tons readily on 3,500 tons displacement, while the most that has ever been in the "New Orleans" bunkers, as far as is known—and certainly what was in her bunkers when displacing the 4,000 tons referred to above—was less than 750 tons.

I do not pretend to criticise the design or construction of the "New Orleans," but she is essentially a "show" vessel, cleverly designed to that end, but not such a design as would be found emanating from the British Admiralty or from our Navy Department. Briefly stated, she was designed purely for speed and the heaviest battery the law would allow. With her extra length of about 50 feet she will not maneuver as well as the "Denver" class; with her extra draught of about 3 feet she is considerably handicapped for work in shallow harbors; with her heavy battery (of little advantage, considering the small amount of ammunition carried) she could not stand the weight of a flush upper deck, and even without it her top weights are such that, particularly without the water-line protection of cellulose provided for the "Denver" class, she is not nearly so well prepared to stand punishment as will be those vessels. Her powerful machinery and large battery necessitate a crew out of all proportion with the accommodations provided, and considerable objection has been filed, by those connected with the ship, in regard to the unsatisfactory provision for officers and crew, including boat capacity for very little more than half the number. Her auxiliary appliances for lighting, heating, refrigerating, etc., were, in some cases, omitted in the original design, or were meager and unsatisfactory, and have had to be added since, with increased weight.

There are different standards for comparison in cases like the one in point, and facts even may be distorted so as to delude the unpracticed reader. The article I have referred to, in addition to being not entirely correct, was very misleading, though probably not intentionally so; some of the original information, relative to the "New Orleans," published in the annual report of the Bureau of Construction and Repair for last year having itself been found since to be not entirely correct.

There is also room for considerable differences of opinion in determining the elemental characteristics of a design. Personally, however, I believe our experience with the "Cincinnati" and "Raleigh" was a sufficient illustration of what to expect from crowding machinery and battery into a small cruiser at the expense of cruising efficiency. I predict great usefulness for the "Denver" class, as well as considerable popularity among sea-going officers.

[The "prominent scientific paper" referred to above is the SCIENTIFIC AMERICAN, and the illustrated article is one which appeared in the issue of September 2, 1899, comparing the "Denver" class design with the "New Orleans." The "gross error" did not originate with the SCIENTIFIC AMERICAN, the displacement of the "New Orleans" as given in the article being taken from the 1898 report of the Bureau of Construction and Repair, of which bureau Admiral Hichborn is chief, where it is given as 3,437 tons when the "New Orleans" is "equipped for sea, all stores on board," with 700 tons of coal in the bunkers. We raised the total to 3,500 tons to allow for 60 or 70 tons of extra coal due to close stowage.—ED.]

* Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1899.

The total length of the streets, avenues, boulevards, bridges, quays, and thoroughfares of Paris is set down at about six hundred miles. Two hundred miles are planted with trees.

MAGNETO-OPTIC ROTATION AND ITS EXPLANATION BY A GYROSTATIC SYSTEM.*

THE action of magnetism on the propagation of light in a transparent medium has been rightly regarded as one of the most beautiful of Faraday's great scientific discoveries. Like most important discoveries it was no result of accidental observation, but was the outcome of long and patient inquiry. Guided by a conviction that (to quote his own words) "the various forms under which the forces of matter are made manifest have one common origin," he made many attempts to discover a relation between light and electricity, but for very long with negative results. Still, however, retaining a strong persuasion that his view was correct, and that some such relation must exist, he was undiscouraged, and only proceeded to search for it more results, as here shown, in the propagation of a wave of the quantity concerned.

In fact, we have here a representation of a wave of plane polarized light. The directions of vibration are right lines parallel at all points along the wave. Ordinary light consists of vibrations the directions of which are not parallel if rectilinear, and each vibration is therefore capable of being resolved into two in directions at right angles to one another. The Nicol's prism, in fact, splits a wave of ordinary unpolarized light into two waves, one in which the vibrations are in one plane containing the direction in which the light is traveling, the other in a plane containing the same direction, but at right angles to the former. One of these waves is stopped by the film of Canada balsam in the prism and thrown out of its course, while the other wave is allowed to pass on undisturbed.

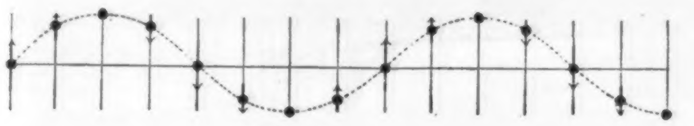


FIG. 1

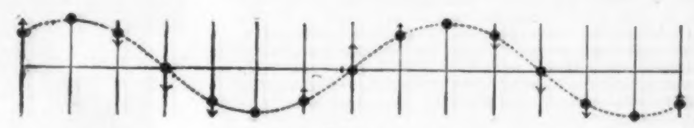


FIG. 2.

strictly and carefully than ever. At last, as he himself says, he "succeeded in magnetizing and electrifying a ray of light, and in illuminating a magnetic line of force."

Faraday pictured the space round a magnet as permeated by what he called lines of force; these he regarded as no mere mathematical abstractions, but as having a real physical existence represented by a change of state of the medium brought about by the introduction of the magnet. That there is such a medium surrounding a magnet we take for granted. The lines of force are shown by the directions which the small elongated pieces of iron we have in iron filings take when sprinkled on a smooth horizontal surface surrounding a horizontal bar magnet, as in the experiment I here make. [Experiment to show field of bar magnet by iron filings.]

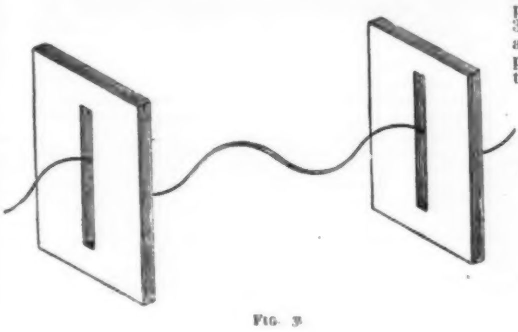


FIG. 3.

The arrangement of these lines of force depends upon the nature of the magnet producing them. If the magnet be of horseshoe shape, the lines are crowded into the space between the poles; and if the pole faces be close together and have their opposed surfaces flat and parallel, the lines of force pass straight across from one surface to the other in the manner shown in the diagram before you. [Diagram of field between flat pole faces.]

The physical existence of these lines of force was demonstrated for a number of different media by the discovery of Faraday to which I have already referred, and on which almost all the later work on the relation of magnetism of light has been founded. I am permitted by the kindness of the authorities of this institution to exhibit here the very apparatus which Faraday himself employed, though for the various experiments I have to make it is necessary to actually use another set of instruments. [Apparatus shown.] Before repeating Faraday's experiments, let me describe shortly what I propose to do, and the effect to be observed.

A beam of plane polarized light is produced by passing white light from this electric lamp through a Nicol's prism. To understand the nature of plane polarized light, look for a moment at this other diagram (Fig. 1). It represents a series of particles displaced in a certain regular manner to different distances from the mean or equilibrium positions they originally had along a straight line. They are moving in the directions shown by the arrows and with velocities depending on their positions, as indicated by the lengths of the arrows. Suppose a certain interval of time to elapse. The particles will have moved in that time to the positions shown in this other diagram (Fig. 2) on the same sheet. It will be seen that the velocities as well as the positions of the particles have altered: but that the configuration is the same as would be given by the former diagram moved through a certain distance to the left.

Thus an observer looking at the particles and regarding their configuration would see that configuration apparently move to the left: and this, it is very carefully to be noted, is a result of the transverse motions of the individual particles. In another interval of time equal to the former the arrangement of particles will appear to have moved a further distance of the same amount toward the left.

This transverse motion of the particles, thus shown displaced from their equilibrium positions, represents the vibration of the medium which is the vehicle of light, and the right to left motion of the configuration of particles is the wave motion resulting from that vibration. I do not say that the medium is thus made up of discrete particles, or that the different portions of it vibrate in this manner, but there is undoubtedly a directed quantity transverse to the direction in which the wave is traveling, the value of which at different points may be represented by the displacements of the particles, and which varies in the same manner, and

If the wave thus allowed to pass by one Nicol's prism be received by another, it is found that there are two positions of the latter in which the wave passes freely through the second prism, and two others in which the wave is stopped. The prism can be turned from one position to another by properly placing it and then turning it round the direction of the ray. It is found that if the prism be thus turned from a position in which the light is freely transmitted, we come after turning it through 90° to a position in which the light is stopped, and that if we go on turning through another angle of 90° a position is reached in which the light is again freely transmitted, and so on, the light being alternately stopped and transmitted by the second prism in successive positions 90° apart.

The mode of passage of the wave by the Nicols when their planes are parallel, and its stoppage when the planes are crossed, are illustrated by this diagram (Fig. 3) of a vibrating cord and two slits. When the slits are parallel, the vibration which is passed by one is passed by the other; when they are crossed, a vibration passed by one is stopped by the other.

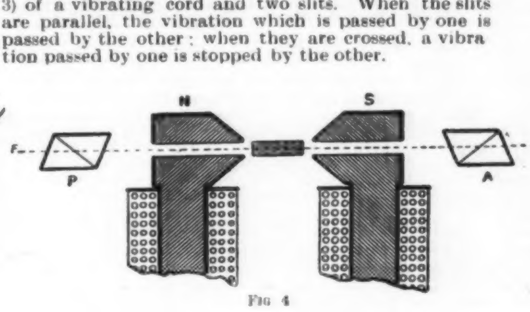


FIG. 4

Two planes of symmetry of the prisms parallel to the ray, and called their principal planes, are parallel to one another when the light passes through both, and are perpendicular to one another when the light passed by the first is stopped by the second. We shall call the first prism the polarizing prism, or the polarizer, from its effect in producing plane polarized light; the other, the analyzer. The stoppage of the light in the two positions 180° apart of the second prism and its passage in the two intermediate positions show that the light passed by the first prism is plane polarized.

Now a beam of plane polarized light is passed through the perforated pole-pieces of this large electro-magnet (Fig. 4), so that the beam travels between the pole faces along the direction which the lines of force there would have if the magnet were excited by a current. The arrangement of the apparatus is as shown in the diagram. The light is polarized by the prism, P, passes through the magnetic field, and then through the analyzing prism, A, to the screen. As you see, when the second prism is turned round the ray, the light on the screen alternately shines out and is extinguished, and you can see also that the angle between the positions of free passage and extinction is 90°.

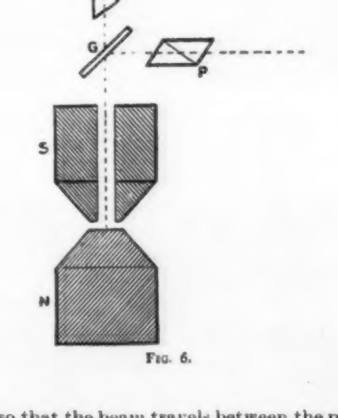


FIG. 6.

I now place in the path of the beam this bar of a very remarkable kind of glass, some of the properties of which were investigated by Faraday. It is a very dense kind of lead glass, which may be described as a silicated borate of lead; that is, it contains silica, boric acid, and lead oxide. The beam is not disturbed, although the light passes through the glass from end to end. I now adjust the analyzing prism to very nearly complete extinction, and then excite the magnet. If the room is sufficiently darkened, I think all will see that when the magnet is excited there is a very perceptible brightening of the dim patch of light on the screen, and that this brightening disappears when the current is removed from the magnet. This is Faraday's discovery.

How are we to describe this result? What effect has been produced by the magnetic field? It is clear that the direction of vibration of the light emerging from the specimen of heavy glass has been changed relatively to the prism, so that the light now readily passes. It is found, moreover, that the amount of turning of the direction of vibration round the ray is proportional to the length of the specimen, so that the directions of vibration at different points along the wave within the specimen lie on a helically twisted surface, and may be regarded as represented by the straight rods in the model before you on the table (Fig. 5).

It is also found that the amount of the turning depends on the intensity of the magnetic field—is, in fact, simply proportional to that intensity. Hence the turning is proportional to the mean intensity of the field, and to the length of the path in the medium, that is, to the products of these two quantities. It also depends on the nature of the medium. The angle of turning produced by a field of known intensity when the ray passes through bisulphide of carbon has been very carefully measured by Lord Rayleigh, whose results are of great value for other magnetic work.

The law of proportionality of the amount of turning of the plane of polarization to the intensity of the magnetic field in the space in which the substance is placed is not, however, to be regarded as established for

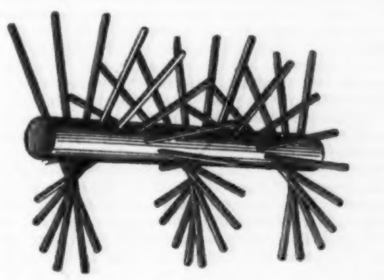


FIG. 5.

strongly magnetic substances, such as iron, nickel, or cobalt. The matter has not yet been completely worked out, but the turning in such cases seems to be more nearly proportional to the intensity of magnetization, a different quantity from the intensity of the magnetic field producing the magnetization. If this law be found correct, the angle of turning will be proportional to the product of the intensity of magnetization and to the length of the path; and the angle observed divided by this product will give another constant, which has been called Kundt's constant.

The rotation of the plane of polarization in strongly magnetized substances was investigated by Kundt, the very eminent head of the Physical Laboratory of the University of Berlin, who died only a year or two ago. Kundt is remembered for many beautiful methods which he introduced into quantitative physical work; but no work he did was more remarkable than that which he performed in magneto-optic rotation when he succeeded in passing a beam of plane polarized light through plates of iron, nickel, and cobalt. Such substances, though apparently opaque to light, are not really so when obtained in plates of sufficient thinness. In sufficiently thin films all metals, so far as I know, are transparent, not merely to Roentgen rays, but to ordinary light. Kundt conceived the idea of forming such films of the strongly magnetic metals, so as to investigate their properties as regards magneto-optic

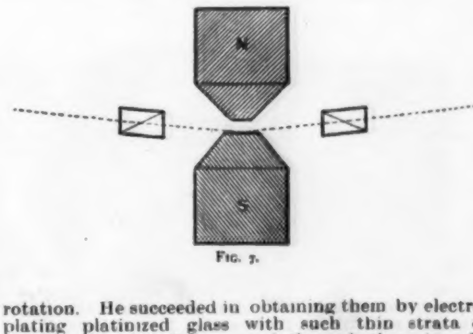


FIG. 7.

rotation. He succeeded in obtaining them by electroplating platinized glass with such thin strata of these metals that light passed through them in sufficient quantity for observation. The rotation produced by the glass and the exceedingly thin film of platinum was determined once for all and allowed for. Kundt obtained the remarkable result that the magnetic rotatory power in iron is so great that light transmitted through a thickness of one centimeter of iron magnetized to saturation is turned through an angle of over 200,000°, that is, that light passing through a thickness of an inch of iron magnetized to saturation would have its plane of polarization turned completely round more than a thousand times; in other words, one complete turn would be given by a film less than $\frac{1}{1000}$ of an inch in thickness. A scarcely smaller result

* A discourse delivered at the Royal Institution by Prof. Andrew Gray, F.R.S.

has been found by Du Bois for cobalt, and a maximum rotation of rather less than half as much by the same experimenter for nickel.

The direction of turning in all the cases which have so far been specified—that is, Faraday's glass, bisulphide of carbon, iron, nickel, and cobalt—is the same as that in which a current of electricity would have to flow round the spires of a coil of wire surrounding the specimen so as to produce the magnetic field. This we call the positive direction. There are, however, many substances in which the turning produced by the magnetic field is in the contrary or negative direction; for example, ferrous and ferric salts of iron, chromate and bichromate of potassium, and in fact most compound substances which are feebly magnetic.

Faraday established by his experiments the fact that substances fall into two distinct classes as tested by their behavior under the influence of magnetic force. For example, an elongated specimen of iron, nickel, or cobalt, if freely suspended horizontally between the poles of our electro-magnet, would set itself with its length along the lines of force. On the other hand, a similar specimen of heavy glass, or a tube filled with bisulphide of carbon, would, if similarly suspended, set itself across the lines of force. The former substances were therefore called by Faraday paramagnetic, the latter diamagnetic.

It might be supposed that diamagnetics would show a turning effect opposed to that found in paramagnetics, but this is not the case. As we have seen, bisulphide of carbon and heavy glass, which are diamagnetics, show a turning in the same direction as that produced in iron—as indeed do most solid, fluid, and gaseous diamagnetics. Feebly paramagnetic compound substances, on the other hand, produce negative rotation.

A theory of diamagnetism has been put forward in which the phenomena are explained by supposing that all substances are paramagnetic in reality, but that so-called diamagnetic bodies are less so than the air in which they are immersed when experimented on. Thus the diamagnetic quality is one of the substance relatively to air, in the same kind of way as the apparent levity of a balloon is due to the fact that its total weight has a positive value, but is less than that of the air displaced by the balloon and appendages. Lord Kelvin's dynamical explanation of magneto-optic rotation does not bear out this view of the matter.

Before passing to the dynamical explanation, however, I must very shortly call attention to some remarkable discoveries in this subject made by Dr. John Kerr, of Glasgow. I have here an electro-magnet arranged as in the diagram before you (Fig. 6). The light from the lamp is first plane polarized by the Nicol, *P*, then it is thrown on the piece of silvered glass, *G*, and part of it is thereby reflected through this perforated pole piece so as to fall normally on the polished point of the other pole piece. Reflection thus takes place at perpendicular incidence, and the reflected light is received by this second Nicol. When the magnet is unexcited the second Nicol is arranged so as to quench the reflected light. The magnet is then excited, and it is found that the light is faintly restored, showing that an effect on the polarization of the light has been produced by the magnetization. It is to be noticed here that the incident and reflected light is in the direction of magnetization. We shall not pause to make this experiment. It was arranged this morning and successfully carried out; but the effect is slight, and might not be noticeable without precautions, which we have hardly time to make, to exclude all extraneous light from the screen.

It would perhaps be incorrect to say that the plane of polarization has been rotated in this case, as it has been asserted by Righi that the light after reflection is no longer plane polarized, but that there are two components of vibration at right angles to one another, so related that the resultant vibration is not rectilinear but elliptical. There is therefore no position in which the analyzing prism can be placed so as to extinguish the reflected light. The transverse component necessary to give the elliptic vibration is, however, in this case, if it exists, very small, and very nearly complete extinction of the beam can be obtained by turning the analyzing prism round so as to stop the other component vibration. The angle through which the prism must be turned to effect this is the amount of the apparent rotation. The direction of rotation is reversed by reversing the magnetism of the reflecting pole. Dr. Kerr found that the direction is always that in which the current flows in the coils producing the magnetization of the pole.

Dr. Kerr also made experiments with light obliquely incident on a pole face, with the arrangement of apparatus shown in this other diagram (Fig. 7). He found that the previously plane polarized light was by the reflection rendered slightly elliptically polarized. A slight turning of the analyzing Nicol was necessary to place it so as to stop the vibration corresponding to the long axis of the ellipse and so secure imperfect extinction.

These effects are, like those of normal incidence, very small, and they can hardly be shown to an audience.

(To be continued.)

THE NEW BRIDGE AT ROUEN.

In certain cases, the selection of a style of bridge to be constructed is a very difficult matter. This is especially so in cities situated inland and considered as maritime ports, such as Bordeaux, Nantes, Caen, Rouen, etc. In such cities, the street traffic is always very heavy and the passage from one shore to the other gives rise to a continuous movement during which it is indispensable that navigation shall not be interfered with. As a general thing, the difficulty is surmounted by the use of a revolving bridge, although such a system does not always satisfy all the requirements of the problem, since it causes a notable loss of time, is expensive and cumbersome, and, in case of damage, may completely arrest the passage of boats. At any rate, it becomes impracticable when the maritime traffic is very heavy. In such an event, no bridge at all is constructed, and pedestrians and vehicles are obliged to make a wide detour.

Such was the case at Rouen, a port that has so greatly developed in recent years, in the wake of new arrangements and the construction of petroleum basins, that the shipping, which a few years ago represented 900,000 tons, will this year figure 2,000,000. So the Chamber of Commerce of the city resolved to render the new installations truly practical by seeking an economical method of connecting the two shores without interfering with the passage of ships, and at the same time obviating the necessity of street traffic making a detour by the Boieldieu bridge, while the distance apart of the two shores is but 490 feet.

The examples of the transshipping bridges at Nervion in Spain, and at Bizerte in Tunis, and the excellent results that they have given, decided the Chamber to adopt this solution of the problem, which is new to France. In pursuance of this resolution, such a bridge has now been established.

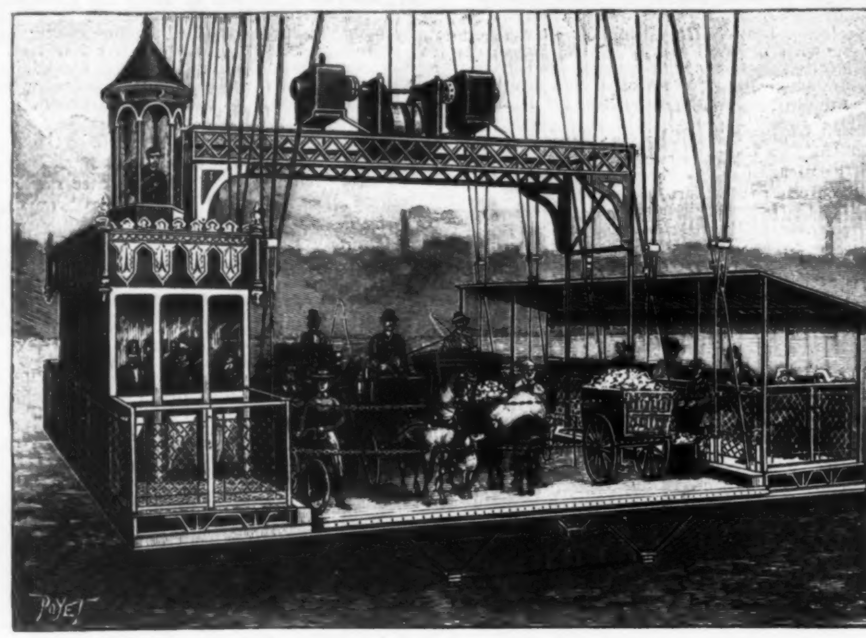


FIG. 2.—THE CAR OF THE NEW BRIDGE.

Two steel latticework towers, 218 feet in height, were constructed upon each of the banks of the Seine at a hundred and fifty yards below the Boieldieu bridge. An endeavor was made to give these, as far as possible, the form of a solid of equal resistance and of very light structure. Between these two points of support was thrown a sort of suspension bridge composed of a horizontal flooring held by cables stretched between the tops of the towers. This flooring had to be placed high enough to permit of the easy passage of the largest vessels that are accustomed to pass up and down the river, and therefore a height of 167·25 feet was chosen, this being amply sufficient.

This flooring, which is not designed for the use of the public, carries four rails upon which run rollers to which are fixed vertical steel cables that support a car of special form situated exactly at the level of the public road on the wharves (Fig. 2).

In order that the tension produced by the weight of the flooring and the car may not pull the towers inwardly, the latter are held in the rear by a series of cables anchored in masses of strong masonry forming monoliths of great resistance.

The car, which is 36 feet in width and 42·5 in length, is provided in the center with a carriageway 26·25 feet in width upon which vehicles may stand, while foot-passengers remain upon the sidewalks. Over one of these latter is constructed a cabin for the use of first class passengers, while upon the latter is installed a simple shelter for those of the second class.

The car, when empty, weighs 20 tons, and the rolling frames and cables have the same weight. It is supposed that the movable load of full vehicles and the foot-passengers represents 65 tons at a maximum, and so the total mass that has to be carried from one shore to the other is 105 tons.

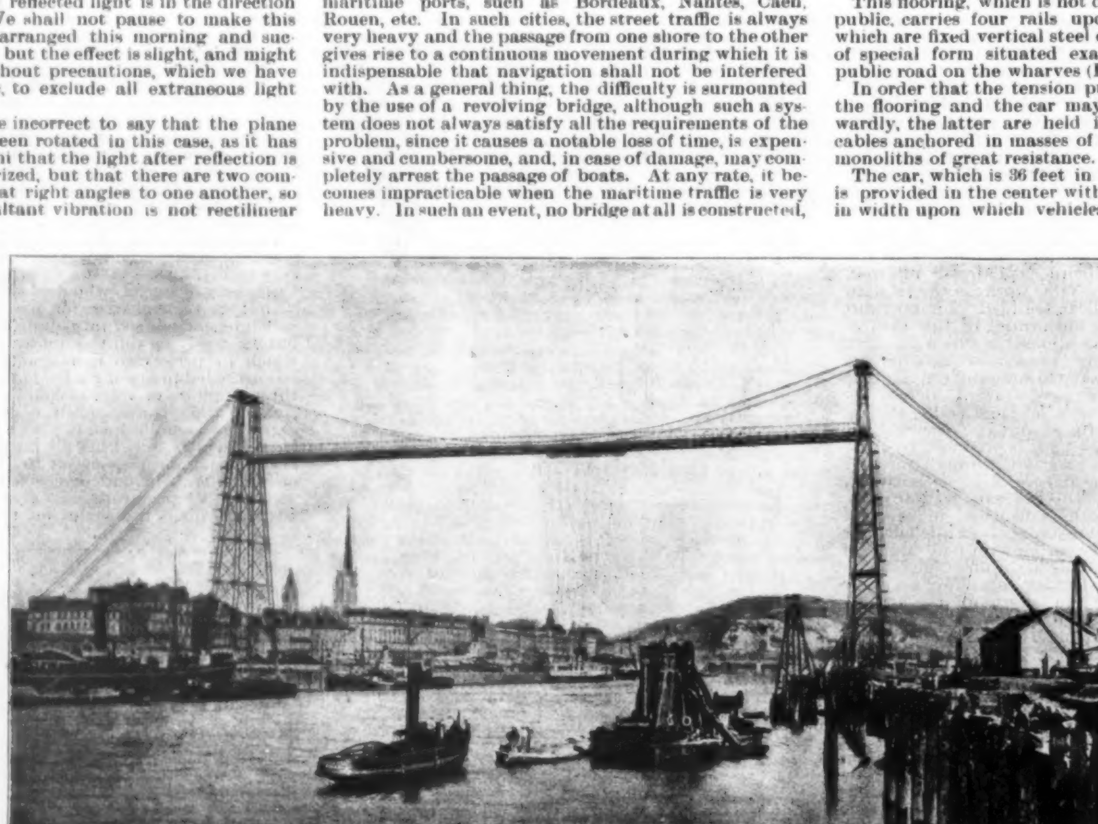


FIG. 1.—GENERAL VIEW OF THE NEW BRIDGE AT ROUEN.

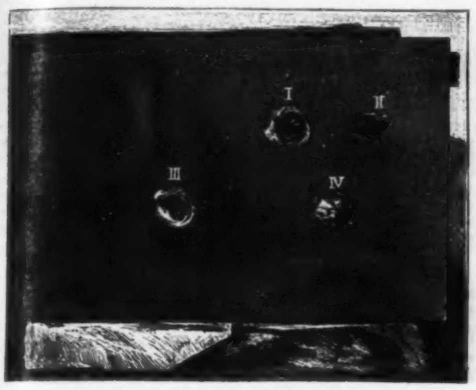


FIG. 1.—Krupp 300 mm. (11·81 in.) Compound Plate. (Front.) Gun, 28 cm. (11·02 in.) Range, 118 m. (128·62 yds.)

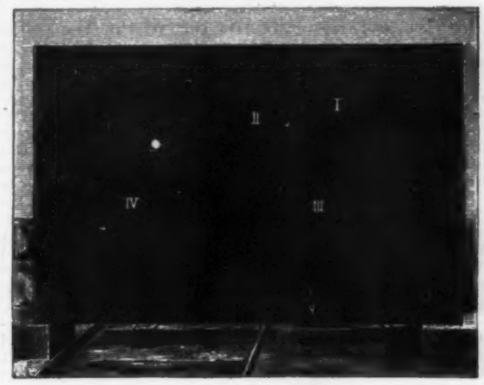


FIG. 2.—Back of Krupp 300 mm. (11·81 in.) Compound Plate. Gun, 28 cm. (11·02 in.) Range, 118 m. (128·62 yds.)

FIG. 3.—Front of Krupp 400 mm. (15·748 in.) Compound Plate. Gun, 30·5 cm. (12 in.) Range, 115 m. (125·35 yds.)

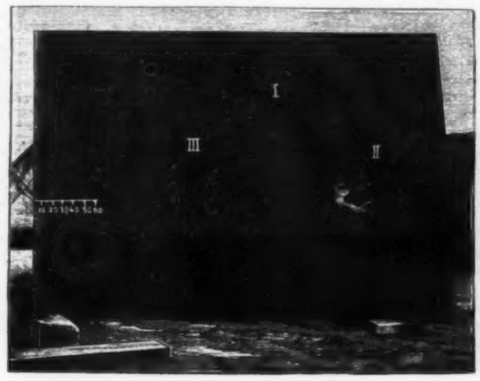


FIG. 4.—Back of Krupp 400 mm. (15·748 in.) Compound Plate. Gun, 30·5 cm. (12 in.) Range, 115 m. (125·35 yds.)

The car is suspended by means of thirty cables arranged in a diagonal combination so as to form a rigid whole which shall not swing in any direction.

As each of the cables is affixed to two rollers, there are sixty of the latter that move upon the upper flooring. If we divide the 105 tons of total load by 30, we shall see that each cable will work at 3,850 pounds. This minimum figure offers absolute security, and it may even be said that it is in this that consists the perfect safety assured by this work.

As an excess of precaution, all the parts have been doubled, so that if, for any reason, one of them should happen to break, the service may continue without interruption while repairs are making. Finally, we may add that a system of counterpoises renders derailment impossible.

The work on this bridge was begun in April, 1898, and is now finished, and it therefore took but a year to effect it. The rapidity with which it was done was principally due to the electric apparatus that was employed. At Rouen there is as much electricity to be had as may be desired, and at a low price. It was possible to install upon the banks some very powerful electric cranes, which served for the putting in place of the different parts of the towers, and all that the workmen had to do was to assemble them at once with rivets. After the towers were finished, the cables that were to support the flooring were put in place, and the flooring itself was then constructed through the intermedium of a flying scaffold.

The car is run electrically through the intermedium of apparatus placed in a deck house in which an engineer can actuate them and know the exact moment of starting and landing.

The fare is two cents for first-class passengers, one cent for second-class, five cents for empty vehicles, and eight cents for loaded ones.

The Chamber of Commerce of Rouen allowed but $12,000 for the construction of the bridge, this sum, added to the toll, being judged amply sufficient to cover the cost of installation and exploitation. For the above particulars and the illustrations we are indebted to La Nature.

KRUPP ARMOR-PLATE TESTS.

ON the great Krupp proving grounds near Meppen, where the battle between armor plate and gun has been waged for many a year, there may be seen huge iron plates shattered by projectiles, the tokens of the gun's victory. But when Krupp undertook the making of plates, it was hoped that a new aspect might be given to the unequal contest. That these hopes have been realized is shown by the accompanying illustrations of recent Krupp armor plate tests, taken from Stein der Weisen.

The new armor plate is made of that tough, nickel-steel alloy which has been used with such success on many of our modern battleships. It is noteworthy that the projectiles are not embedded in the new plate but are reflected or thrown back to a considerable distance, either shattered or entire. Harder plates were also tested, which, without being cracked, broke up the projectiles into small pieces.

Nowadays we distinguish the compound armor plate from the metal alloy (nickel and uranium steel) plate. The former consists of a soft iron back upon which is welded a hard steel face. The Krupp nickel-steel plates are superior to the old time compound armor, for they have the merit of being capable of withstanding even the largest projectiles without cracking.

Fig. 1 represents a 300 mm. (11·81-inch) plate of compound armor, whose weight was 19·96 kg. (43·91 pounds), length 360 cm. (11·8 feet), and width 240 cm. (7·87 feet). In making the test a 28 cm. (11·02-inch) gun was used at a range of 118 m. (128·62 yards). The projectile was a chilled iron shell weighing 234 kg. (514·8 pounds), and the powder charge weighed 43 kg. (94·6 pounds). Four of these projectiles were fired. The plate was not even cracked.

Fig. 3 represents a 400 mm. (15·748-inch) plate, whose length was 360 cm. (11·7 feet), width 253 cm. (8·298 feet), and weight 28 kg. (61·6 pounds). The gun used was a 30·5 cm. (12-inch) rifle, and the range 115 m. (125·35 yards). The projectiles employed were two chilled iron shells weighing 323·7 kg. (712·14 pounds), the powder charge being 100 kg. (220 pounds), and a steel armor-piercing shell weighing 325 kg. (715 pounds), the powder charge being 91 kg. (200·2 pounds). The chilled shot were completely broken up and their heads fused in the plate. The armor-piercing shells were hurled back 12 m. (39·36 feet) without suffering any deformation. The resistibility of this plate is equivalent to that of an iron plate 580 mm. (22·83 inches) in thickness.

Fig. 5 represents a 300 mm. (11·81-inch) nickel-steel plate whose weight was 20·33 kg. (44·726 pounds), length 331 cm. (10·8568 feet), and height 258 cm. (8·46 feet). The range was 119 m. (129·71 yards). The projectiles were four Krupp steel armor-piercing shells and one chilled iron shell, fired from a 28 cm. (11·02-inch) gun. Of the four steel projectiles, I. weighed 231 kg. (508·2 pounds), II. 233 kg. (512·6 pounds), III. 232 kg. (510·4 pounds), IV. 233 kg. (512·6 pounds), and V. the chilled iron shell, 229 kg. (503·8 pounds). The powder charge for all five weighed 62 kg. (136·4 pounds). The steel armor-piercing shell was deflected without any deformation, and the chilled shell was broken up, the head remaining embedded. The plate was not cracked.

Fig. 7 is a 400 mm. (15·748-inch) plate of nickel-steel weighing 28 kg. (66·6 pounds). The range was 116 m. (126·44 yards); the projectiles four Krupp steel armor-piercing shells and one chilled iron shell fired from a 30·5 cm. (12-inch) gun. Of the four Krupp steel shells, I. weighed 325·7 kg. (716·54 pounds), II. weighed 325·3 kg. (715·66 pounds), III. 323 kg. (713·9 pounds), IV. 325·2 kg. (715·44 pounds), and the chilled iron shell V. weighed 326 kg. (717·2 pounds). The weight of the powder charge was 94 kg. (206·8 pounds). The armor-piercing shells were deflected and broken up. The chilled iron shells were completely shattered, the heads remaining embedded. The plates were uncracked. The resistibility of the plate to penetration was equal to that of an iron plate 700 mm. (27·559 inches) in thickness.

TEXTILE DESIGNS BY PHOTOGRAPHY.

PROFESSOR Roberts Beaumont, in his introductory address in opening the session of the evening classes of Yorkshire College, described the new photographic process of preparing textile designs invented by Jan Szczepanik, which has attracted much attention, and his remarks on the subject are reported in The Textile Mercury.

On behalf of the Yorkshire College, Professor Beaumont recently went to Paris to investigate the invention. One of the results of his visit was that a number of specimens of designs prepared by the new process were on view in the lecture room. Professor Beaumont also secured the loan of some of the actual apparatus used by Szczepanik.

Professor Beaumont prefaced his address by saying that he had spent a considerable time in examining the inventions of Szczepanik, and had seen designs worked out by the new process in the temporary premises in Paris. He also stated that the Szczepanik Company have already a plant for the preparation of designs at work in Barmen, and that they are about to form a company for the same purpose in Great Britain. The object of the photographic appliances of Szczepanik was to take the artistic sketch, and without any modification of the same, to enlarge it to scale, to transfer it on to ruled paper or point paper, and mark it with the thousands and millions of dots arranged in the proper orders for the development of the several parts of the pattern, in the weaves necessary for giving to each suitable precision of character when woven. The methods of working the designs

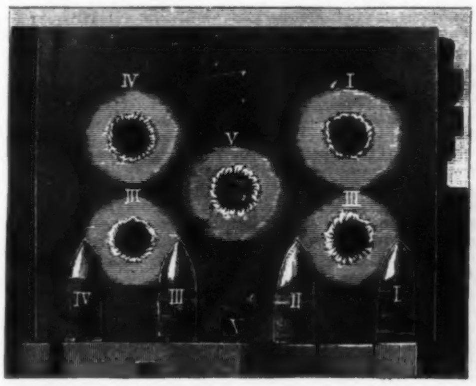


FIG. 5.—Front of Krupp 300 mm. (11·81 in.) Nickel-steel Plate. Gun, 28 cm. (11·02 in.) Range, 119 m. (129·71 yds.)

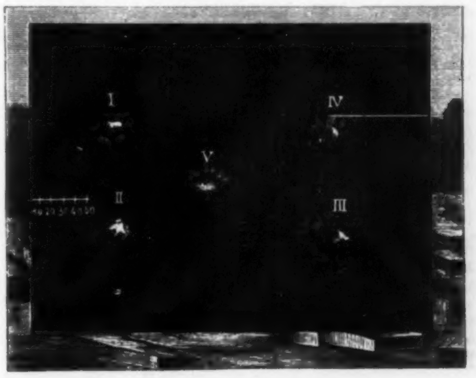


FIG. 6.—Back of Krupp 300 mm. (11·81 in.) Nickel-steel Plate. Gun, 28 cm. (11·02 in.) Range, 119 m. (129·71 yds.)

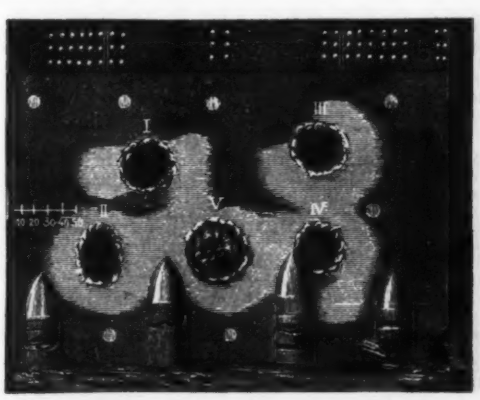


FIG. 7.—Front of Krupp 400 mm. (15·748 in.) Nickel-steel Plate. Gun, 30·5 cm. (12 in.) Range, 116 m. (126·44 yds.)

FIG. 8.—Back of Krupp 400 mm. (15·748 in.) Nickel-steel Plate. Gun, 30·5 cm. (12 in.) Range, 116 m. (126·44 yds.)

KRUPP ARMOR-PLATE TESTS.

were explained by lantern slides, diagrams, designs, and experiments. Professor Beaumont observed that it had been made plain that the apparatus of Szczepanik was capable of producing designs in which there was considerable diversity of woven detail, so that it was purely a question of whether the designs thus obtained were legible for all practical purposes. It was recognized that there must be limitations to its utility, as there were to all automatic and mechanical appliances. Yet if it could be employed in accelerating the process of designing large patterns, it should have the serious attention of all who desired the further development of the weaving industries. It had been thought by some that if the invention became commercially useful, the sphere of the designer would be considerably restricted. This was an unsound doctrine to hold in regard to mechanical and scientific innovation. The place of the designer, the brain worker in textile factories, where fancy and decorative textures are produced, could not be assailed.—Journal of the Society of Arts.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Parcels-post Exchanges with Germany.—The convention recently signed between the government of the United States and Germany, extending to both countries reciprocally the advantages of a public parcels-posts service, will be of vast importance and benefit to the retail trade and exchange of mercantile samples between the two countries, and the facilities thereby offered should be generally understood.

Hitherto, says Consul Frank H. Mason, of Berlin, much difficulty and many complaints have been caused by a certain carelessness on the part of many American exporters in sending packages of small value, without any definite idea of what the cost of transmission might be and a consequent neglect to provide for them.

A few practical examples from recent experience will illustrate this point:

An importer in Hamburg had occasion to order from a firm in the United States a small package of fine bicycle fittings, valued at about $7. The express charges on the package to Hamburg (75 cents) had been prepaid. The local agent through whom the goods were delivered presented a bill for miscellaneous charges amounting to 7·20 marks ($1.72). The profit on the sale of the fittings by the importer was only 15 cents, so that the transaction was spoiled for him by the additional charges for transmission.

The same dealer ordered some samples of other wares from a Western firm, who shipped the goods through an express company, marked "Collect charges on delivery." The eighteen articles had been ordered at an advertised price free on board at New York, and sold to arrive at a price which yielded a small profit, the main object of the importer being to introduce the goods by sample to dealers in Germany. They arrived with a freight bill of 60 marks ($14.28), including the express charges from factory to port of shipment. This was an average of 3 marks, or 72 cents, on each article, which entailed a loss to the importer, so that the goods were refused for noncompliance with the advertised or agreed terms of sale.

Henceforth, it will be possible for shippers in both countries to send, prepaid, postal packages not exceeding 5 kilogrammes (10½ pounds) in weight, with absolute certainty that they will be delivered without any other charge than import duty, which can be accurately calculated—all German duties being specific—and provided for by previous agreement.

Suppressing the San José Scale in Canada.—After prohibiting the importation of "nursery stock" into Canada, the government of Ontario appointed a commission of three professors to investigate the ravages of the San José scale and the efficacy of the means adopted for stamping it out. The commission has made a final report, the main points of which I summarize, says Commercial Agent Gustave Beutelspacher, of Moncton.

The greatest infestation, they say, is in one corner of Niagara township, near Niagara-on-the-Lake, and the township of Harwick, Kent County, in the neighborhood of the post office of Gould. There is limited infestation at Kingsville, and smaller ones at St. Catherines, Winona, Burlington, and near Chatham. In ninety-one other cases, trees planted within the last two years were found infested. These were all destroyed, and this year's inspection failed to discover scale in any but thirteen out of the ninety-one places. The scale was found in five nurseries, but the infested stock was destroyed. The inspector estimated it would be necessary to destroy 136,200 trees, to be reasonably sure of exterminating the scale.

The commissioners are in doubt as to the possibility of checking the further spread of the scale and eventually exterminating it by the destruction of the trees, as provided by the San José scale act. They advise the immediate destruction of all badly infested trees, showing incrusted trunks; the careful treatment of all others, and the granting of large discretionary powers to the inspectors in dealing with isolated cases of infestation. The work of treating them should be done by the Government, and the owners of the trees should pay for the material and board the men and horses during the time of treatment. Owners of trees not so badly infested should be required to treat them by a prescribed method once a week.

Owners of trees should be paid one-fourth of their value without discount, the fruit on the tree to be regarded as part of its value. The fumigation of nursery stock should be done under official supervision, and nurserymen should be required to attach a certificate of fumigation to every parcel of stock sold.

Leather Industry in Cape Colony.—United States Consul J. G. Stowe, of Cape Town, says: An association of colonial manufacturers recently sent a committee to call upon the prime minister of this colony, to urge a special tariff on certain lines of manufactured goods that, it is alleged, are being produced in the colony and other goods that might be produced, together with the free admission of all raw materials entering into the manufacture of said goods, to the end that the present manufactures may be fostered and other industrial enterprises inaugurated. The association also desires free interchange of all South African products and manufactures throughout the states and territories of South Africa, the same to be brought about by a new "customs union." The claim is made that leather tanning, boot and shoe manufacture, saddle and harness making, furniture and cabinet making, and biscuit making which can consume large quantities of South African products are languishing for want of adequate protection against imported manufactures. Fruit preserving is mentioned as an instance where the admission of raw material free is necessary for the development of an established industry. In the opinion of the association, it is necessary for the encouragement of colonial industries that all manufactures in which colonial products or colonial labor represents 50 per cent. of the total value, should be carried over the several systems of railways at third-class rates.

It is claimed that the tariff on leather goods was unable to stop the importation of goods which competed with those produced here. The manufacturers say that the Americans are sending boots and shoes and leather into this country, while colonial manufacturers cannot send their goods into America under a duty of 25 per cent. for boots and shoes, and 45 per cent. for harness. They claim that all they want is sufficient protection to place them on the same footing as their English and American competitors. The present duty in Cape Colony on boots and shoes and leather goods is 9 per cent.

In reply to the request, the prime minister stated, in substance, that South Africa would never be largely a manufacturing country, and that in the matter of boots and shoes the colonial manufacturers could not begin to supply the needs of the country. He would not promise any action, but suggested that they appoint a committee and submit suggestions as to the tariff.

I speak of this for the reason that, within the past year, manufacturers of the United States have been paying more attention to the introduction of American made boots and shoes, conforming to the English patterns, and have also been active in the saddlery and harness line.

American Bridge in the Sudan.—Ambassador Choate transmits from London, August 28, 1899, clipping from The Morning Post, giving the speech delivered by Lord Kitchener at the opening of the bridge over the Atbara River, in the Sudan, as follows:

DIFFICULTIES OF CONSTRUCTION.

I have great pleasure in declaring the Atbara Bridge open, and I congratulate you all very heartily upon the excellent work which has enabled us to add another record of construction to our railway achievement. It was not until 1896 that railway construction was commenced in the Sudan, and it is satisfactory to note that we have to-day 587 miles of line actually working north of the bridge, and 122 completed south, thus leaving 75 before reaching our goal—Khartum. During the work we have had many grave difficulties to overcome, principally caused by the military necessity of constructing the line without any proper detailed surveys. We all remember how, when pushing the line across the Desert toward Abu Hamed, at the time when that place was still held by the Dervishes, we had to trust the accuracy of our direction to local information and our own good luck. I am thankful to say that even under those conditions, the line was so laid out that had we to make it again in perfect peace no change would be, in my opinion, necessary.

DAMAGE BY STORMS.

Another great difficulty has been the constant washouts, which, I am sorry to see, have done so much damage. In 1896, we had 17 miles completely washed away in one day, and no sooner was the damage repaired than a further washout carried away another 10 miles of line. This year I regret to learn that, though our line to the Atbara is now so well bridged as to prevent any serious breakdown, on the unbridged 120 miles to the south so much damage has been done by storms that our work has been delayed from one and a half to two months. In a country where such violent tempests are prevalent at this time of the year, it is impossible to avoid these contretemps, which I am glad to see are being faced and overcome with the splendid spirit always shown by our officers and men.

As regards this magnificent bridge, gentlemen, I think we may fairly claim that it is a record achievement. It was only well into last October that the credits were authorized for the extension of the line to Khartum. The sites of the bridge had then to be determined, the borings, soundings, and sections of the river had to be completed, and eight solid double piers to carry the superstructure had to be sunk down to the rock below the river bed to meet the Atbara flood, which arrived twenty-five days earlier than our experience led us to expect. But, gentlemen, this did not catch us napping. Owing to the energy displayed, the piers were completed more than twenty-five days earlier than was thought possible. When the flood wave came it passed harmlessly, carrying away only the temporary bridge by which we pushed on railway construction to the southward.

PLACING THE ORDER.

In November and December, every effort was made to place the order for the superstructure in England, but it was found impossible for British firms to supply so big an undertaking in the time allowed. This matter is one of considerable regret to me personally. I think it demonstrates that the relations between labor and capital in our country are not such as to give sufficient confidence to capitalists to induce them to run the risk of establishing great up-to-date workshops with the plant necessary to enable Great Britain to maintain her proud position as the first constructing nation of the world. Well, gentlemen, where Englishmen have failed I am delighted to find our cousins across the Atlantic have stepped in. The opening of this bridge to-day is due to their energy and ability and the power they possess in so marked a degree of turning out works of this magnitude in less time than can be done by anyone else. I congratulate the American foremen and workmen on the excellent success which has crowned their efforts in the erection of this bridge in the heart of Africa, far from their homes, during the hottest months of the year, and depending solely upon the labor of men speaking a foreign tongue. They have shown by their work the real grit they are made of. I should also like to mention the excellent work of Messrs. Thomas & Company, by whom the piers have been built, and, while offering both firms our best thanks, I think, gentlemen, you must fully realize how impossible it would have been for me to carry out this railway construction in anything like the time or at anything like the cost, had it not been for the indefatigable zeal of the young officers of my own corps, who have been responsible for this great work, as well as for the untiring efforts of the Egyptian officers, non-commissioned officers, and men who have been employed on it.

New Steamship Line to Antwerp.—Under date of Antwerp, September 13, 1899, Consul-General Lincoln says:

I have received this day from Messrs. Steinmann & Co., agents of the Leyland line of steamships, information regarding the establishment of a direct service by steamers of the above-mentioned line between Antwerp and Portland, Me. It is the intention to maintain a fortnightly service between the ports mentioned, and the sailings for the near future are fixed as follows for this port: Steamship "Almerian," leaving on the 15th of November; steamship "Albanian," leaving on the 29th of November; steamship "Assyrian," leaving on the 16th of December; steamship "Almerian," leaving on the 30th of December.

Postal Shipments to Russia.—Consul Monaghan, of Chemnitz, under date of August 4, 1899, transmits the following instructions relative to postal shipments to Russia:

When a letter is found in a package sent by post, note of same will be made and signed by the customs official in charge. This note will contain the name of the place whence the letter comes, whither it is to go, when sent, and for whom and from whom. The letter is to be taken out and sent with the above mentioned note to the postal authorities at the place whence the package came. A package containing a letter is to be sent forward to the addressee, under general regulations. The letter will also be delivered upon the party to whom it is addressed paying a fine. In case such payment is refused, the letter is to be forwarded to the general post office. In cases where packages from foreign parts contain letters or notes or circulars in open envelopes, even though they have the character of correspondence, such inclosures will not be removed. The package, with its inclosures, will be delivered to the parties to whom it is addressed.

Chinese Mining Regulations.—Minister Conger sends from Pekin, August 12, 1899, copy of amendments to the regulations governing railways and mines in China, sanctioned and promulgated on July 30. The regulations were printed in Advance Sheets No. 355 (February 20, 1899); Consular Reports No. 223 (April, 1899). The inclosure in the present dispatch is in the form of a memorial drawn up by the Bureau of Railways and Mines in conjunction with the Tsungli Yamên. It reads:

"In the matter of railways, on the 13th of December, 1898, the Yamên, conjointly with the mining and railway bureau, memorialized the throne in reference to a thorough consideration having been given to the management of railways and to the need of making a distinction between those that are urgent and those that can be delayed. The suggestions made received the imperial sanction and were duly promulgated and are a matter of record."

United States vs. German Trade in Argentina.—Consul Winter, of Annaberg, under date of August 15, 1899, writes that in a recent article the Deutsche Export Zeitung, of Berlin expatiates on the danger to German exports to Argentina in the increasing American competition. Among other things, the article says:

"The efforts made by American business men are certainly worthy of emulation. American commercial travelers appear in every city and town, and work in unison with local agents of the various products. Exhibition rooms for samples have been established in all the larger cities, and the country has been simply flooded with catalogues and price lists.

"Here, as everywhere in the world's markets, we must prepare for a hard battle with American competition. It will need all our energy and resources to enable us to hold our own."

Inspection of Forestry in Canada.—The department has received the following from Commercial Agent Beutelspacher, dated Moncton, August 30, 1899:

An inspector of timber has been created by the Dominion Government. With the view of preserving the remaining forests upon Dominion lands and Indian reserves from utter destruction by fires and other destructive agencies, and of encouraging the reproduction of forest trees and also, as settlement is rapidly progressing in all parts of Manitoba and the Northwest Territory, with the object of making an immediate inspection of the country, to ascertain what tracts should be set apart for timber reserves before they are encroached upon by settlers, the position of Chief Inspector of Timber and Forestry has been created. The headquarters of the inspector will be at Ottawa and his salary will be $2,500 per annum.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Antiseptic "Mouth Pearls," produced by Radlauer, are small sugar globules containing 0·001 gramme each of thymol, menthol, eucalyptol, saccharin, and vanillin. They are used as a substitute for tooth, mouth, and throat wash.—Neueste Erfindungen und Erfahrungen.

Adhesive Belt Grease.—Heat 2 kilogrammes of cut-up caoutchouc with 2 kilogrammes of rectified oil of turpentine to 60° C. As soon as the caoutchouc is dissolved, add 1 kilogramme of ceresine or else ½ kilogramme of paraffine and ½ kilogramme of ceresine, until same has also melted.

Into another vessel of suitable size, put 5 kilogrammes of fish oil and 2 kilogrammes of tallow; heat until all is melted and pour the caoutchouc solution in with constant stirring. The mass becomes solid when cold.—Seifensieder Zeitung.

Protecting Seed from Sparrows, etc.—With every spring commences for the owner of a garden the trouble with sparrows, which, despite all precautionary measures, promptly rob the beds of their freshly sown seed. The author has used for two years with faultless success perforated pieces of tin for covering up the rows of seed. The tins are bent on the long side into the shape of a roof. By placing the tins together the rows are provided with an airy roof, under which the seedlings, specially peas and spinach, can develop undisturbed. In windy weather the tins must be fixed here and there by a small twig stuck into the ground. The tins are waste from button factories and last for at least ten years.—Practische Rathgeber im Obst- und Gartenbau.

Production of Natural and Artificial Lemon Juice.—From the fruit: Boil 10 parts of freshly expressed and filtered lemon juice with 18 parts of sugar.

In order to obtain a bright filtrate, it is advisable to agitate the lemon juice with talcum, which should first be treated with diluted hydrochloric acid, and then washed out well with water, and to allow to settle. The juice if preserved in small bottles will keep for an unlimited period. Artificial lemon juice: a. Dissolve 1 to 2 parts of citric acid in equal volumes of water, mix with 100 parts of sugar sirup and flavor with 1 to 2 parts of a tincture prepared in the ratio of 1 to 5 from fresh lemon peel by means of 60 per cent. alcohol. b. Dissolve 8 grammes of citric acid and 4 grammes of tartaric acid in 12 grammes of spirit and 25 grammes of water, add 40 grammes of lemon essence (lemon oil 75 grammes, alcohol 5 liters) and 1 kilogramme of sugar sirup.—Zeitschrift für d. g. Kohlensäure-Industrie.

Protection Against the Bursting of Frozen Pipes.—Same consists in a rubber lining which admits of the water expanding when freezing in the pipes, without exerting a pressure upon the walls of the pipes which would cause them to burst.

A second, more narrow, and very thin-walled pipe of tin or lead is inserted in the whole length of the conduit pipe. The interior of the former is filled with an elastic rubber mass, which withstands the ordinary pressure without changing its shape. When the water on freezing exercises an increased pressure, the elastic lining is pressed together according to the increase in the volume of the ice. During the thawing out, the rubber core expands again and regains its original circumference. The rubber is surrounded by tin or sheet lead, so as to obviate a direct contact of the water with the rubber mass, thus preventing the water from acquiring the unpleasant smell and taste peculiar to rubber. A large series of freezing tests demonstrated that the pipes with linings remained perfectly intact, while those without lining cracked.—Neueste Erfindungen und Erfahrungen.

Varnishing Sheet Zinc.—In order to obtain durable coatings on sheet zinc, various propositions have been made, e. g., tinning the sheet by the wet process, corroding with hydrochloric acid to produce a rough surface, etc. During his fifteen years connection as technician with a large clock dial factory in the Badish Black Forest, Mr. J. Miller, painter at Esslingen, had many opportunities to test the said recipes and to make experiments for the production of a durable coating. He found, says Die Werkstatt, that corroding with hydrochloric acid is suitable only for cast goods. For sheet metal the rubbing down (roughening), though more laborious, is the safer method. For this purpose the cut-out and well leveled dials (other articles of sheet zinc may be rubbed off with powdered pumice stone by means of a ticking rag) are rubbed down, wet, owing to the harmful dust, on the side to be lacquered, with fine sand or pumice stone, until no more dark spots are seen, and dried well. For the first coat all paints produced from lead, copper and iron are unsuitable. From dial plates which had been varnished with Krems' white, probably without previous priming, the lacquer cracked off upon the slightest bending or peeled off, although the metal had been roughened by rubbing down. Between paint and metal was found a gray powder or dust, probably a deposit from the zinc, which detracted from the durability. Hence the first coating upon white ware should be made with zinc white or else with ordinary white lead containing more extenders than white lead. Lacquerings with quick-drying paints are absolutely unsuitable. Use fat but well-drying oil varnishes, etc., and allow the goods to dry off two to three times every twenty-four hours at a heat of 60° to 70° R. (140° to 158° F.) Linseed oil varnish which is used for this purpose must not be boiled with lead oxide but with zinc vitriol (stannic sulphate) or manganese. For dark colors and black, Miller has successfully used the brown siccative which comes in stone jars.

Storing varnished zinc goods in damp places is injurious even to the most carefully executed lacquering. Miller arrived at the following final conclusion as a result of his experiments: Paints produced from iron, copper and especially lead, applied immediately upon the rubbed-down (roughened) zinc surface, do not last even when the application is sufficiently fat, so that it seems advisable to put a neutral coating of any zinc or earth color, e. g., chalk, between the metal and the chief color or else to rub the metal very sparingly on both sides with the above named brown siccative, using the flat hand, and allowing to dry well. For black, this is not necessary.

MISCELLANEOUS NOTES.

The great difficulty hitherto experienced with cast or wrought iron objects coated with enamel is the unequal expansion and contraction of the two substances, this causing a splintering of the enamel; but M. Sagliot lately brought before the French Société d'Encouragement pour l'Industrie Nationale the results of his experiments in this connection, that have enabled him to constitute a whole series of enamels having various degrees of expansion. It appears that enamels containing cryolite, fluorspar, and a little rutile, or native titanic acid, possess very high degrees of dilatation, and that cast or wrought iron, coated with calcareous enamels containing no lead, which are not at all injurious, may be formed by using boric acid.

The leakage of steam from the steam pipes of various kinds of plants using ordinary amounts of piping is probably much greater than is generally believed. Mr. R. S. Hale, in The Engineering Magazine, states that he has found the following proportions of steam to be lost in this way when exposed by tests:

Mills	5 to 16 per cent.
Electric plants	2½ to 7 "
Steamships	1½ to 10 "
Waterworks	2½ "

The proportion of loss depends upon whether the plant is worked up to its full capacity. If the electric plant with a loss of 7 per cent. is working at one-third of its capacity, the loss is 21 per cent. of the steam actually used.

The Signs and Tests of Death.—1, Cessation of respiration—*a*, Mirror test: *b*, feather test; *c*, water or mercury test; *d*, stethoscopic test; *e*, rhythmic traction of the tongue. 2, Cessation of circulation—*a*, Stethoscopic test; *b*, ligature test; *c*, scarification and cupping; *d*, opening of an artery; *e*, needle test (Cloquet's); *f*, fluorescine test; *g*, injection of ammonia (Monte Verde's test); *h*, diaphanous test (Carriere's); *i*, Roentgen ray. 3, Changes in the eye—*a*, Test by bright light; *b*, test by mydriatics; *c*, test by ophthalmoscope; *d*, test by ophthalmatonometer. 4, Loss of animal heat—temperature test. 5, Loss of sensation and of motion—*a*, Electric test; *b*, heat test; *c*, caustic test. 6, Muscular flaccidity and contractility. 7, Cadaveric ecchymoses, lividity, or hypostases. 8, Cadaveric rigidity, cadaveric spasm, rigor mortis. 9, Putrefaction.—Medical Record.

Investigations made at Purdue University, in Indiana, do not bear out the current belief that locomotive sparks are the cause of the greater number of the forest fires. In the Indiana experiments a series of large pans were placed at distances of 15, 25, 50, 75, 125, 175, 275, and 375 feet from a railroad, at a point where there was a heavy grade and where many freight trains passed daily. Each pan was covered with soft cotton cloth, so that if live cinders reached them the fact would be known by scorched or burned places in the cloth. When the experiments were concluded, it was found that the greatest number of sparks or cinders had fallen in the pans fifty and seventy-five feet from the track. The largest cinder did not equal the size of a white bean, while in no instance was the cloth in the pans even scorched. The inference was that if the cinders were hot when they left the smoke-stacks, they had lost their heat in traveling the fifty or seventy-five feet. This would indicate that fires communicated from locomotives are rare.—New York Evening Post.

Effect of Magnetization on the Modulus of Elasticity.—At a recent meeting of the American Association for the Advancement of Science, Professor J. S. Stevens, University of Maine, in a paper with the above title stated that it has already been found that temperature changes affect the modulus of elasticity. This experiment tested the effect of magnetization. Steel and wrought iron bars 60 by 1 by 0·64 centimeter were used, and loads of 1 kilogramme and ½ kilogramme fastened to the center. These caused a deflection. When the rods were magnetized by forces ranging from 199 to 126 C.G.S. units, the deflection was decreased, showing that magnetization increases the modulus. The change in deflection was increased by an interferometer, one plate of which was fastened to the bar, and the motion read in wave lengths of light. Temperature changes were guarded against, (1) by a stream of water flowing between coil and rod; (2) by testing with a sensitive thermometer; (3) by noticing that the change in deflection was always sudden; (4) by discovering no change in a copper rod. The measurements were not considered sufficiently exact to enable it to be stated that there is a regular relation between magnetic force and the modulus increased with the magnetizing force.

Those whose business takes them past the "heart" of the City—the Bank of England, the Royal Exchange and the Mansion House—will know the disorganized state of the roadway at this point, caused by the various underground electric-railway workings now approaching completion, says The London Mail. In front of the Royal Exchange is the City terminus of the Central London Railway, whose line to Shepherd's Bush, via Oxford street and Notting Hill, is making rapid progress. Opposite are the entrances to the Waterloo and City Railway, opened to the public in August last. At the junction of Lombard street and King William street is arising the new City station of the City and South London Railway, which will by the autumn of this year be able to convey passengers from Clapham Common to Moorgate street in twenty-one minutes. Another eight minutes will, after the end of 1900, take the passenger to the Angel, and he will thus be able to journey from North to South London within the half-hour. By the end of 1902 the Great Northern and City Railway from Finsbury Park to Moorgate street is expected to be complete. Capital will probably shortly be asked for by the City and Brixton Railway, which proposes to construct a line from the present King William street terminus of the City and South London Railway to Brixton, passing via St. George's Circus under the Kennington and Brixton roads. Yet another projected line is the Charing Cross, Euston and Hampstead. All these lines will be electrically worked, and the Metropolitan Railway is at present conducting experiments with a view to adopting that power on its existing system.—Boston Transcript.

SELECTED FORMULÆ.

Bath Tablets.—An English formula for "bath tablets" is the following:

1. Sodium carbonate	4	ounces.
Tartaric acid	1½	"
Orris root	½	"
Oil of lemon	½	drachm.
Oil of orris (or ionone)	5	minims.
Oil of ylang-ylang	5	"

Mix the oils with the orris root, add the other ingredients and make into a stiff paste with alcohol. Divide into suitable sized tablets and dry.

2. Powdered borax	4	ounces.
Salicylic acid	1	drachm.
Essence of cassie	1	fluid drachm.
Essence of jasmine	1	"
Oil of lavender flowers	20	drops.

Rub the oil and extracts with the borax and salicylic acid and form into tablets with a little alcohol.

BATH POWDER.

Tartaric acid	10	ounces.
Sodium bicarbonate	9	"
Rice flour	6	"

Perfume with a mixture of the following oils:

Oil of neroli	2	fluid drachms.
Oil of rosemary	1	"
Oil of bergamot	1	"
Oil of cedrat	2¼	"
Oil of orange	2¼	"

A fluid drachm of this mixture is sufficient to perfume a pound of the above bath powder.—Pharmaceutical Era.

Battery Fluid.—The National Formulary gives two formulas for a bichromate fluid to be employed with the ordinary zinc and carbon battery. Here are some others:

1. Mercury bisulphate	120	grains.
Potassium bichromate	2¼	ounces.
Commercial sulphuric acid	3	fluid ounces.
Water	16	"

In the water first dissolve the mercury bisulphate and then the bichromate; then add the sulphuric acid very carefully, stirring constantly with a glass rod. When cool the solution is ready for use. The mercury keeps the zincs well amalgamated. Sometimes the mercury salt is omitted, and frequently sodium bichromate is substituted for the potassium bichromate.

2. Trouve's Solution for Bichromate Batteries.—The proportional parts by weight are: Potassium bichromate, 1 part; sulphuric acid, 3 parts; water, 6·6 parts. To charge a gallon of water according to this method, dissolve it in 24 ounces of potassium bichromate and then gradually add 9 pounds of sulphuric acid.

3. Bottone's Battery Fluid.—This solution consists of chromic acid, 6 parts; water, 20 parts; potassium chlorate, ½ part; and sulphuric acid, 3½ parts (by weight). There is said to be no danger, provided the potassium chlorate be dissolved before the sulphuric acid is added. The addition of potassium chlorate to sodium bichromate gives it greater staying powers; but not so markedly as in the case of chromic acid unless a large excess of sulphuric acid is used to neutralize both the sodium and potassium.

Nearly Smokeless Flash-Light.—Dr. Lainer, in The Photogr. Corresp., recommends perfectly dry ammonium nitrate as an addition to magnesium as a flash producer far superior, at all points, and especially in the matter of the evolution of smoke, to any other substance yet suggested or used. It may be added to the magnesium in any proportion, from equal parts up to 3 parts of magnesium to 1 of the nitrate, according to the rapidity of flash desired. "Already," says the professor, "in the proportion of 30 centigrammes of magnesium to a gramme of the nitrate, a light sufficient to make excellent negatives of the carte de visite size is obtained."

His recommendation as to burning is to cut a slip of niter-paper 0·4 inch wide and 2 inches long, and to strew the powder on the end of it. This is touched off on a tin plate or any convenient bit of metal. The essentials for success with this powder are: Absolute dryness of the ammonium nitrate; it must be reduced to the finest possible powder; the mixture should be made on paper, using a quill as a mixer, and finally, the use of either pyroxylin or niter paper, as described, as a lighter.

Paste in Powdered Form.—Some years ago a patent was granted for an adhesive paste consisting of a compound containing flour, starch, or other farinaceous substance, with an alkali, preferably caustic soda or caustic potash, or some other strongly alkaline substance. If the flour be mixed with any of these substances in the form of powder in the proper proportions they form a compound which, when mixed with water, will soon assume the consistence of a paste, and will become soluble in water. The action of the alkali on the flour bursts the starch cells and digests or dissolves it, increasing its bulk and reducing it to a paste, which may be thinned by the addition of water or thickened by the addition of more of the alkali and flour. These compounds are sold as powders, to be mixed with water by the user.

The following formula has been given:

Flour	84 parts.
Caustic soda (pulverized)	8 "

In place of the caustic soda, pulverized caustic potash may be used. Other forms of alkali—such as strong soda ash—may also be used, but the quantity must be considerably increased until sufficient to digest the flour. It is preferably best to employ caustic soda.

A formula said to answer better for all purposes is the following modification of the above:

Flour, starch, other farinaceous substance	84 parts.
Pulverized caustic soda (or potash)	8 "
Ammonium sulphate	8 "

To apply it to use, add to it a little water.

The ammonium sulphate is used as a neutralizing agent and counteracts the strong effects of caustic soda on colored or tinted papers.

THE EFFECT OF HYDROCYANIC ACID GAS UPON THE GERMINATION OF SEEDS.*

THE primary object of the experiments recorded in this paper has been to determine the physiological effect of hydrocyanic acid gas upon grains and other seeds. The importance of this series of investigations appears when we consider the rapidly increasing use of this gas in treating insects infesting stored grains. The destructive influence of hydrocyanic acid gas upon animal life is well known; while the effect of this gas upon vegetable organisms has received little attention. However, we should not overlook the valuable work done along this line by Drs. Loew† and Woods, of the United States Department of Agriculture. The former experimented with the poison in dilute solution, while the latter used the gas generated by the action of dilute H_2SO_4 upon KCN.

In generating hydrocyanic acid gas for the experiments herein recorded, the potassium cyanide was carefully weighed and at the proper time was placed in a mixture of water and sulfuric acid. In the early experiments the seeds to be tested were placed in open shallow dishes and introduced into the fumigating boxes in which my colleague, Prof. Johnson, was testing the action of gas upon nursery stock. In this manner the seeds were exposed to the gas obtained from 0·25 gramme potassium cyanide per cubic foot as the minimum and 1·45 grammes per cubic foot as the maximum; and in each case the exposure was continued for one hour.

After removing the seeds from the influence of the gas and soaking them in water for twenty-four hours, they were placed in the germinating pan. At the same time similar seeds that had not been subjected to the influence of the gas were placed under the same conditions for control. At the end of several hours it was found that the seeds that had been treated germinated just as readily as if they had not been subjected to the influence of this gas. While this seems to establish the point in question so far as rapid fumigation is concerned, it is sometimes desirable to subject the grains for several consecutive hours; as, for example, in the fumigation of mills, barns, granaries, etc. Since the grain under these circumstances may sometimes be damp and it may be necessary to use large quantities of gas, it becomes desirable to know what effect may be produced on seeds if fumigated in damp or moist conditions with different quantities of gas. In order to reach definite results in regard to these points, it became necessary to devise certain means by which the seeds to be tested could be kept for an indefinite period in gas chambers and, at the same time, to generate a gas in the chambers without allowing any part of it to escape. In order to fulfill these conditions, bell jars with ground glass stoppers were employed, each jar having a capacity of approximately one-third cubic foot. In order to generate the gas in one of these jars, the mixture of sulphuric acid and water was placed in a watch glass which was allowed to rest in the center of one of the ground glass plates, so that when the bell jar was placed upon the plate the stopper was directly over the dish of dilute acid. The desired amount of potassium cyanide was very carefully weighed out and folded in thin tissue paper; a string, just the length of the jar, was then fastened at one end to the lower surface of the glass stopper and at the other end to the package of potassium cyanide. The latter was lowered into the glass jar, and just at the instant that the potassium cyanide came into contact with the dilute acid, the stopper was in proper position to close the jar.

The seeds to be treated were placed under the bell jar just before the potassium cyanide was introduced; so that as soon as the gas was generated, the seeds were surrounded by gas. In the jars in which dry seeds were to be subjected to the influence of the gas, it was only necessary to place the seeds in glass dishes of suitable size and to introduce them at the proper time under the bell jars. In those jars, however, in which the moist seeds were to be tested, the seeds were first soaked in water for a definite length of time and then spread upon damp blotting paper. The bell jars that were to cover the seeds were transformed into damp chambers by lining them with damp filter paper. The seeds employed were wheat, oats, corn, beans, cabbage, and clover seed.

While there are, in some instances, marked differences in the behavior of the different seeds, the results were generally the same. It will, therefore, be understood that all seeds subjected to the same treatment give the same general result, unless otherwise specified. In one jar containing dry seeds, one gramme of potassium cyanide per cubic foot was used, and in another jar also containing dry seeds, one-third of a gramme of potassium cyanide was employed. At the expiration of fifteen days samples of seeds were taken from each dish in each jar, soaked twenty-four hours, and placed on moist filter papers in the damp chambers containing atmospheric air only. In from two to eight hours thereafter all of the seeds that had been in the gas had germinated; while those in the control experiments did not germinate under twelve hours; hence we see that hydrocyanic acid gas under these circumstances tended to accelerate germination. Growth continued normal in all these seedlings until they were overcome by fungi, at which time the roots and shoots had obtained a growth varying from two to eight inches. (See cut showing the bell jars as used.)

BELL JAR SHOWING THE GROWTH OF SEEDLINGS IN A DAMP CHAMBER.

The seedlings produced from the seeds subjected to the stronger atmosphere of gas grew more rapidly than those in the control experiments. It should be stated in this connection, however, that the difference in the time of germination, as well as the difference in the rate of growth of the seedlings, was not sufficient to be of any practical importance, although the fact is shown that even dry seedlings are not without sensitiveness to the presence of hydrocyanic acid gas. Immediately after removing samples of the seeds for the purpose of testing their germinating power as just described, the remaining seeds were returned to the bell jars and new charges of gas, of the same strength as before, were introduced. At the expiration of sixty days from the time the seeds were first introduced into these jars samples were again removed and tested as before, with the result that in both cases germination was slightly accelerated as compared with the control experiments.

Contrary to the preceding test, however, the seeds subjected to the weaker charge of gas (namely, one-third gramme per cubic foot) germinated first. The seedlings from these seeds grew more rapidly than those from the seed that had been in the stronger atmosphere of gas. At the end of three days the rate of growth was distinctly in proportion of two to one in favor of the weaker charge of gas; yet, while this proportion was maintained for a short time only, the difference was marked even at the end of six days. Hence, it appears that dry seeds may be exposed to very strong charges of hydrocyanic acid gas for many weeks without in any degree retarding their germination or interfering with the subsequent growth of the seedlings.

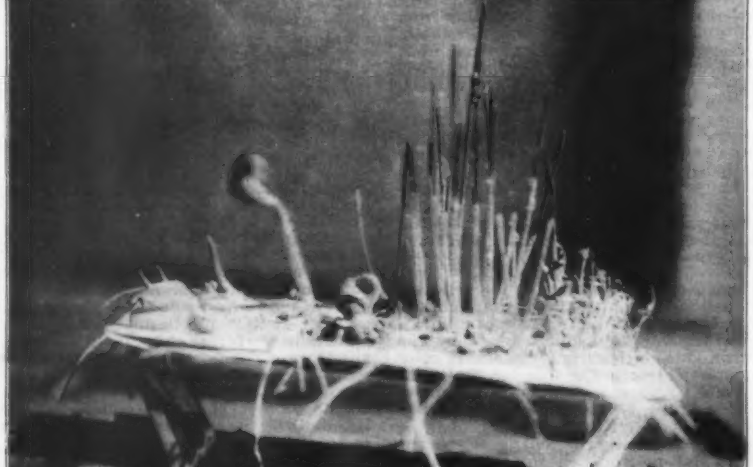
In the case of moist seeds it was necessary to determine the maximum and minimum charges of gas in which seeds could germinate in different degrees of moisture. In order to determine this point, the seeds were soaked twenty-four hours and then placed in damp chambers containing different quantities of gas. In no instance did any of the seeds show signs of germination until the quantity of potassium cyanide used was reduced to 0·03 gramme per cubic foot. When this rarity of hydrocyanic acid gas was reached, a few of the seeds showed very slight signs of germination. The time required for germination was very much increased by this amount of potassium cyanide; for instance, while germination in the control experiments took place in about twelve hours, those seeds that were placed in hydrocyanic acid gas produced from 0·03 gramme potassium cyanide per cubic foot showed no signs of germination until ninety-six hours, or even longer. When the weight of potassium cyanide used was reduced to 0·015 gramme per cubic foot, germination took place in seventy-two hours. The leaves and shoots in this instance developed slowly for several days until they became from ¼ to 1 inch in length. Although these seedlings were left for fifteen days in this strength of hydrocyanic acid gas, no further growth was noticed. When 0·01 gramme was used, the seeds germinated in twenty-four to forty-eight hours, while the subsequent growth was very limited. The leaves and roots grew to be about twice as long as those experiments in which 0·015 gramme was used; but, as in the preceding case, they were incapable of further development.

The amount of potassium cyanide was then reduced to 0·006 gramme; but even this retarded germination several hours, and also the subsequent growth of the seedling. Even when the amount of potassium cyanide was reduced to 0·003 gramme per cubic foot, the time of germination was double the time required for germination in the control experiment. Hence the hydrocyanic acid gas obtained from 0·03 gramme potassium cyanide per cubic foot may be taken as the maximum amount of gas in which seeds soaked for twenty-four hours will germinate; while a mere trace of gas may be considered as the minimum amount that will influence germination under these circumstances. If the seeds were soaked only twelve, or even but six, hours and placed in different strengths of hydrocyanic acid gas in the damp chambers, germination took place in the same time, respectively, as if soaked twenty-four hours; although the subsequent growth of the seedlings was, as a rule, more vigorous, indicating that the less moisture the seeds contain, the more resistant they are to this poisonous gas.

In other experiments the seeds were soaked for twenty-four hours in water and then placed in damp chambers containing one-fourth gramme potassium cyanide per cubic foot and left for forty-eight hours, at the end of which time they were removed and placed in damp chambers containing ordinary atmospheric air. Twenty-four hours later the corn had begun to germinate; at the expiration of another twenty-four hours practically all of the corn and wheat had germinated; but none of the cabbage seeds and only one clover seed had germinated even at the end of eight days. It is quite remarkable that while the germination of corn and wheat was comparatively retarded, the subsequent growth was accelerated; for example, at the end of eight days the sprouts of corn and wheat in the control experiments averaged respectively 1¾ and 3 inches, while the roots averaged 2 and 2¾ inches. In the seeds treated with gas, the leaves of corn and wheat averaged 3¼ and 4½ inches respectively, while the roots averaged 4¾ and 3¾ inches respectively. This shows a total acceleration of 1½ inches in the length of the leaves of both corn and wheat; while the roots of the corn showed an acceleration of 2¾ inches and the roots of the wheat 1 inch.

The main facts thus far learned may be briefly stated as follows: Hydrocyanic acid gas in sufficient quantities and for the length of time required for the destruction of insect pests has no effect upon the germination of dry seeds. While dry seeds are not entirely indifferent to the presence of hydrocyanic acid gas, they are able to remain for several weeks in a strong atmosphere of the gas without any appreciable injury to their germinating power. Dry seeds, when left for a considerable length of time in a strong atmosphere of hydrocyanic acid gas, show slight acceleration in germination and in subsequent growth of the seedlings. Seeds that have been soaked for twenty-four hours in water and placed in damp chambers containing hydrocyanic acid gas will not germinate if the amount of potassium cyanide used to generate the gas exceeds 0·03 gramme per cubic foot. Moist seeds may be kept for several days in a damp chamber containing hydrocyanic acid gas without injury to germination; indeed, such seeds germinate more readily and the subsequent growth of the seedlings is more rapid than when hydrocyanic acid gas is not used.

The following table shows concisely the effect of dif-



SEEDS SOAKED TWENTY-FOUR HOURS IN WATER, THEN PLACED IN DAMP CHAMBER FIFTEEN DAYS FOR CONTROL.

* A paper by C. O. Townsend, Pathologist Maryland State Horticultural Department, College Park, Md., read August 24, 1899, at the Ohio State University, Columbus, O., before the Botanical Section of the American Association for the Advancement of Science. Revised by the author especially for the SCIENTIFIC AMERICAN SUPPLEMENT.

† Natur. System der Giftwirkung. Munich, 1898; Bull. Imperial Univ. College of Agri., Vol. I., No. 1, page 34, on the Poisonous Action of Dicyanogen. The Variable Effects of Hydrocyanic Acid Gas on Plants and Animals. Report of Society for Plant Morphology and Physiology. American Naturalist, 1898.

SEEDS SOAKED TWENTY-FOUR HOURS IN WATER, THEN PLACED IN DAMP CHAMBERS. TEMPERATURE 18° TO 20°.

Grammes of K C N per Cubic Foot.	Percentage of Germination of Seeds and Subsequent Growth of Seedlings.					
	12 Hours.	24 Hours.	36 Hours.	72 Hours.	96 Hours.	15 Days.
0·000	80 per cent.	100 per cent.	Steady growth.	Normal growth.	Normal growth.	Normal growth.
0·003	.....	90 "	100 per cent.	Nearly normal growth.	Slightly retarded growth.	About ¾ of normal growth.
0·005	.....	70 "	100 "	Medium growth.	Strongly retarded growth.	About ½ of normal growth.
0·010	.....	50 "	90 "	Strongly retarded growth.	Strongly retarded growth.	No further growth.
0·015	.....	.....	60 "	Strongly retarded growth	Slight growth.	No further growth.
0·020	.....	.....	20 "	40 per cent.	Very slight growth.	No further growth.
0·030	.....	.....	.....	.....	2% had begun to germinate.	No further development.
0·035	.....	.....	.....	.....	.....	No sign of germination.

ferent quantities of hydrocyanic acid gas upon the germination of seeds in a damp condition; the influence of this gas upon the subsequent growth of the seedlings is also shown.

COCKROACHES.

THE term cockroach doubtless gives rise in many of our readers to an intense feeling of disgust. "Is it not

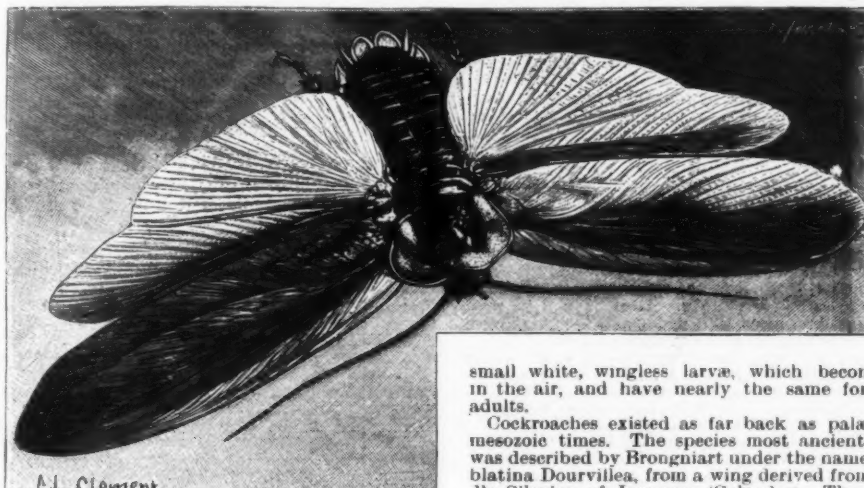


FIG. 1.—GIANT COCKROACH IN THE ACT OF FLYING. (Natural size.)

repugnant," said M. Chapellier recently in the course of a very interesting communication to the Société d'Acclimatation, "to think that a host of foul and stinking beasts has been running all night over the bread and fruit that will be served up to us on the morrow?" We are of M. Chapellier's opinion that such a thought is repugnant, and for this reason we are induced to publish a few lines in order to make better known an enemy whose misdeeds have been only too well known for a long period. The ancients, in fact, complained of these insects, although they de-

FIG. 2.—GIANT COCKROACH AT REST. (Natural size.)

rived an advantage from them that we no longer think of. They knew them under the names of Sylphæ and Spondyles. Dioscorides advised the use of their entrails, brayed with oil, for the cure of otalgia, ophthalmia, contusions, etc. Pliny and Mouffet give the same advice.

The cockroaches, erroneously placed by Linnæus among the Hemiptera, belong to the order Orthoptera. They are very lively in their movements, and their soft and flat body allows them to introduce themselves into the smallest fissures. Their noisome odor, which recalls that of the mouse, remains attached to every object that they have touched. Shunning the light and sensitive to cold, they congregate especially in kitchens, bakeries, pastry shops, hothouses, etc.; and nothing comes amiss to them as food—bread, meat, fruit, sugar, woolen rags, fat, leather, etc. They are distributed throughout the earth, and easily endure a long fast by living upon their reserve fat, and this explains how it is that they are found still alive and numerous in rooms that have been uninhabited for many months.

We shall not describe them, since the accompanying Figs. 1 and 2 sufficiently indicate their general characters.

Oviposition, which ordinarily occurs but once with these insects, presents some interesting peculiarities. The eggs are united in a common oötheca secreted in the interior of the female's body, and which she releases after dragging it for some time at the extremity of her abdomen. From these eggs, which are arranged in the case in two parallel series, there come forth small white, wingless larvæ, which become brown in the air, and have nearly the same form as the adults.

Cockroaches existed as far back as palæozoic and mesozoic times. The species most anciently known was described by Brongniart under the name of Paleoblatina Dourvillea, from a wing derived from the middle Silurian of Jourgues (Calvados). The species at present living are numerous, but only a small number of them interest us from a domestic standpoint. They are the Lapland cockroach (Ectobia lapponica, L.), a yellowish species about four-tenths of an inch in length, with blackish antennæ and corselet. It is met with in all woods in company with an allied species, the Ectobia livida. It is only in Lapland that it has become domesticated to such an extent as to prove a scourge. It swarms there in huts and devours dried fish.

The next species is the German cockroach (Blatta germanica, L.), which is about half an inch in length and of a light brown. It is found in the woods and flies well and this facilitates its diffusion. It is very common in houses, from which, it is said, it is driven by the common cockroach (Blatta orientalis, L.) It was unknown in Russia previous to the seven years war, and was introduced thereinto by the troops, whence the name "Prussian" given it by the Russians, while the Austrians call it "Russian" (Fig. 4). Hummel, who has observed the metamorphoses of this species, attributes to it seven moultings, which take place in five and six months. At the fifth, the rudiments of elytra appear and it becomes a nymph. The

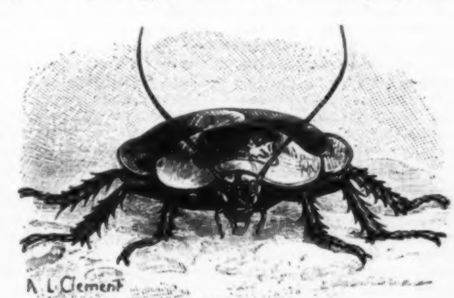


FIG. 3.—GIANT COCKROACH—FRONT VIEW.

oötheca contains two rows of eighteen eggs each. After oviposition, the female opens the case and helps the young ones to escape from it.

The oriental cockroach has become distributed throughout Europe only within the last two centuries. It is about from three-quarters of an inch to an inch in length and of a pitch brown. The female remains wingless, and the male, although winged, flies but little. It sometimes proves noxious to such a degree as to make houses uninhabitable, and to give rise to lawsuits; and it often causes great damage in hothouses. According to Cornelius, who has observed its metamorphoses, it passes one year in the egg state, undergoes seven moultings, and attains its complete development in five years. The oötheca contains but eight eggs on each side.

The American cockroach (Periplaneta americana, L.) measures from one to one and a quarter inch, and is probably indigenous to the Antilles.

Finally, there are some cockroaches that are specially remarkable by reason of their great size, and that fortunately have not yet become distributed throughout Europe. Among these is the giant cockroach (Blabera gigantea, Stoll), represented in Figs. 1, 2, and 3. It is an inhabitant of the tropical regions of America. Its length is about three inches, and its spread of wings exceeds six. According to Drury, it runs over the faces of travelers during the night and also gnaws their nails. It enters houses, and in its peregrinations therein makes a noise that has given it the name of "drummer." It is yellowish, with brown spots.

The methods of destroying cockroaches are not very numerous; yet, if applied with perseverance, they suffice to diminish the number of these foul insects considerably. Old wet rags attract them at night, and in the morning they are easily crushed. M. Chapellier, in the communication mentioned above, recommends the use of the wing-trap (Fig. 5), by means of which he has captured 7,976 oriental cockroaches in four months in a house in which there was no bakery, pastry shop, or kitchen; and he mentions the case of one of his friends whose newly constructed house was completely overrun, probably through the introduction of eggs or young larvæ along with provisions.

"Their radical destruction," says M. Chapellier, "is no more possible than that of flies or other small noxious domestic animals."

A little boiling water poured in the morning into the trap above mentioned suffices to kill all the cockroaches that are confined therein. Unfortunately, this succeeds only with the adults, since the weight of

FIG. 4.—GERMAN AND ORIENTAL COCKROACHES. (Natural size.)

the larvæ is not sufficient to cause the wings of the trap to revolve. It is inefficient likewise against the German cockroach, which easily climbs up the smooth side of the trap and makes its escape.

In the colonies, hinged wooden boxes provided with a long narrow aperture near the bottom are used. These are baited with bacon, and the cockroaches that enter them during the night remain therein till morning, when it is very easy to destroy them. In Havana, toads, which are tolerated in the houses for the purpose, wage continual war upon these insects. According to Walk, the inhabitants of Passau, in order to get rid of cockroaches, sometimes quit their dwellings in midwinter and leave everything open for two or three days. This abrupt change of temperature causes many of the pests to perish. There are several kinds of insecticides used for the destruction of cockroaches, among which powdered pyrethrum holds the first rank.

Cockroaches have many parasites, the Evaniæ and Chalcidians, for example, as well as numerous intestinal worms that have been well studied by Dr. Osman Galeb. On Bourbon and Mauritius islands, the Chlorion, a beautiful hymenopter, paralyzes the Blatta Americana by means of its sting and gives it as food to its larvæ. But the action of all such parasites scarcely diminishes the number of cockroaches, and

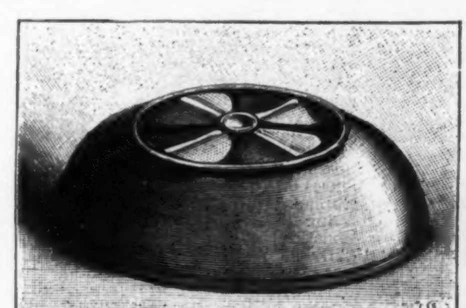


FIG. 5.—COCKROACH TRAP.

unrelenting war must be waged against them by means of traps, insecticides, and other means.

For the above particulars and the illustrations we are indebted to La Nature.

CANADA AS AN EXPORTER.

CANADA is becoming to a certain extent a competitor of the United States as an exporter. While this relates to comparatively few articles, it affects industries which have brought into the United States from abroad many million dollars during the past few years. A recently published statement by the Dominion statistician, Hon. George Johnson, has just reached the Treasury Bureau of Statistics. It shows that the exports of flour, butter, cheese, and wood since confederation, that is from June 30, 1868, to June 30, 1898, amount to $894,000,000. While manufactures of wood form of course the largest item in this enormous sum, cheese, in which Canada becomes a direct competitor of the United States, amounts to the surprisingly large total of $218,241,262; butter, to $58,471,604; and flour to $61,340,182.

Commenting upon this growth in the exportation of

those articles in which Canada competes with the United States, Statistician Johnson says:

"The development of the cheese export trade is marvelous. We sent a little over $500,000 worth of cheese to Great Britain in 1868, and in 1898 we sent $17,522,681 worth, thus far surpassing the exports of the United States, which, last year, to the mother country, were only $3,267,607. Of the total exports of Canadian manufactures in 1898, cheese only formed 3 per cent. in value, while in 1898 it formed over 31 per cent. of the total exports of manufactures. The exports of the manufactures of wood, as is quite natural, occupy the highest place, but they have not increased relatively to the others as rapidly. In 1868 the exports of manufactures having wood as the raw material were 61·7 per cent. of the whole, while in 1898 they were 40·3 per cent. During the thirty years Great Britain has taken of our manufactures of wood over $258,000,000 worth, while the United States has taken $242,000,000 worth, leaving Great Britain the better customer by $16,000,000.

"We have exported since confederation, i. e., from June 30, 1868, to June 30, 1898—thirty-one years—of home products, to the value of $2,464,000,000; or to be exact, $2,464,277,239. These products have been of the farm, the mine, the fisheries, the forest, the workshop and the factory.

"To whom have we sent these products? Our best customer during those 31 years has been the mother country. She has taken more than one-half of the whole, or $1,260,565,563. Our next best customer has been the United States, which country has taken over $955,000,000, or $305,500,000 less than the United Kingdom. The British West Indies come next with purchases from us amounting to $59,945,541. Newfoundland has taken $48,807,362; France, $12,190,654; Germany, $9,089,194; and all other countries, $118,640,647. Great Britain began in 1868 by taking about $18,000,000 of our products. By 1872 she had got beyond $25,000,000; by 1882, nearly $40,000,000; by 1892, beyond $54,000,000; after which year her takings increased steadily till, in 1898, they were over $93,000,000.

"The United States has shown no such activity in buying from us. In 1868 the purchases of that country from us amounted to over $22,000,000. By 1872 they had increased to nearly $30,000,000; by 1882, to $41,700,000. That is the highest figure their purchases ever reached. They have been steadily decreasing, and in 1898 they were only $34,400,000. During the thirty-one years Great Britain's purchases from us have increased five times what they were in the first year of confederation. In the same period the United States' purchases have increased about two-thirds more than they were in 1868. Great Britain, which purchased in 1868 $4,400,000 less than the United States, bought, in 1898, $58,300,000 more than the United States."

[Continued from SUPPLEMENT, No. 1247, page 19996.]

A PROBLEM IN AMERICAN ANTHROPOLOGY.*

THE Inca civilization, a forcible one coming from the north, encroached upon that of the earlier people of the vicinity of Lake Titicaca, whose arts and customs were to a considerable extent adopted by the invaders. It is of interest here to note the resemblance of the older Andean art with that of the early Mediterranean, to which it seemingly has a closer resemblance than to any art on the American continent. Can it be that we have here an æsthetic survival among this early people, and could they have come across the Atlantic from that Eurafric region which has been the birthplace of many nations? Or is this simply one of those psychical coincidences, as some writers would have us believe? The customs and beliefs of the Incas point to a northern origin, and have so many resemblances to those of the ancient Mexicans as hardly to admit of a doubt that in early times there was a close relation between these two widely separated centers of ancient American culture. But how did that pre-Inca people reach the lake region? Is it not probable that some phase of this ancient culture may have reached the Andes from northern Africa? Let us consider this question in relation to the islands of the Atlantic. The Canary Islands, as well as the West Indies, had long been peopled when first known to history; the Caribs were on the northern coast of South America as well as on the islands; and, in the time of Columbus, native trading boats came from Yucatan to Cuba. We thus have evidence of the early navigation of both sides of the Atlantic, and certainly the ocean between could easily have been crossed.

One of the most interesting as well as most puzzling of the many phases of American archæology is the remarkable development of the art of the brachycephalic peoples, extending from northern Mexico northeastward to the Mississippi and Ohio valleys, then disappearing gradually as we approach the Alleghanies and, further south, the Atlantic coast, also spreading southward from Mexico to Honduras, and changing and vanishing in South America. Unquestionably of very great antiquity, this art, developed in the neolithic period of culture, reached to the age of metals, and had already begun to decline at the time of the Spanish conquest. How this remarkable development came to exist amid its different environments, we cannot yet fully understand; but the question arises, Was it of autochthonous origin, and due to the particular period in man's development, or was it a previously existing phase modified by new environment? For the present this question should be held in abeyance. To declare that the resemblance of this art to both Asiatic and Egyptian art is simply a proof of the psychical unity of man is assuming too much, and is cutting off all further consideration of the subject.

The active field and museum archæologist or ethnologist who knows and maintains the associations of specimens as found, and who arranges them in their geographical sequence, becomes intimately in touch with man's work under different phases of existence.

Fully realizing that the natural working of the human mind under similar conditions will to a certain extent give uniform results, he has before him so many instances of the transmission of arts, symbolic expressions, customs, beliefs, myths and languages, that he is forced to consider the lines of contact and migration of peoples as well as their psychical resemblances.

It must be admitted that there are important considerations, both physical and mental, that seem to prove a close affinity between the brown type of Eastern Asia and the ancient Mexicans. Admitting this affinity, the question arises, Can there have been a migration eastward across the Pacific in neolithic times, or should we look for this brown type as originating in the Eurafric region and passing on to Asia from America? This latter theory cannot be considered as a baseless suggestion when the views of several distinguished anthropologists are given the consideration due to them. On the other hand, the theory of an early migration from Asia to America may also be applied to neolithic time.

However this may have been, what interests us more at this moment, and in this part of America, is the so-called "mound-builder" of the Ohio Valley. Let us first clear away the mist which has so long prevented an understanding of this subject by discarding the term "mound-builder." Many peoples in America as well as on other continents have built mounds over their dead, or to mark important sites and great events. It is thus evident that a term so generally applied is of no value as a scientific designation. In North America the term has been applied even to refuse piles; the kitchen-middens or shell-heaps which are so numerous along our coasts and rivers have been classed as the work of the "mound-builder." Many of these shell-heaps are of great antiquity, and we know that they are formed of the refuse gathered on the sites of the early peoples. From the time of these very early deposits to the present such refuse piles have been made, and many of the sites were reoccupied, sometimes even by a different people. These shell-heaps, therefore, cannot be regarded as the work of one people. The same may be said in regard to the mounds of earth and of stone so widely distributed over the country. Many of these are of great antiquity, while others were made within the historic period and even during the first half of the present century. Some mounds cover large collections of human bones, others are monuments over the graves of noted chiefs; others are in the form of effigies of animals and of man; and, in the South, mounds were in use in early historic times as the sites of ceremonial or other important buildings. Thus it will be seen that the earth-mounds, like the shell-mounds, were made by many peoples and at various times.

There are, however, many groups of earth-works which, although usually classed as mounds, are of an entirely different order of structure and must be considered by themselves. To this class belong the great embankments, often in the form of squares, octagons, ovals and circles, and the fortifications and singular structures on hills and plateaus which are in marked contrast to the ordinary conical mounds. Such are the Newark, Liberty, Highbank and Marietta groups of earth-works, the Turner group, the Clark or Hopewell group, and many others in Ohio and in the regions generally south and west of these great central settlements; also the Cahokia Mound opposite St. Louis, the Serpent Mound of Adams County, the great embankments known as Fort Ancient, which you are to visit within a few days, the truly wonderful work of stone, known as Fort Hill, in Highland County, and the strange and puzzling walls of stone and cinder near Foster's Station.

So far as these older earth-works have been carefully investigated they have proved to be of very considerable antiquity. This is shown by the formation of a foot or more of vegetable humus upon their steep sides; by the forest growth upon them, which is often of primeval character; and by the probability that many of these works, covering hundreds of acres, were planned and built upon the river terraces before the growth of the virgin forest.

If all mounds of shell, earth or stone, fortifications on hills, or places of religious and ceremonial rites, are classed, irrespective of their structure, contents, or time of formation, as the work of one people, and that people is designated "the American Indian" or the "American Race," and considered to be the only people ever inhabiting America, North and South, we are simply repeating what was done by Morton in relation to the crania of America—not giving fair consideration to differences while over-estimating resemblances. The effort to affirm that all the various peoples of America are of one race has this very year come up anew in the proposition to provide "a name which shall be brief and expressive," and at the same time shall fasten upon us the theory of unity—notwithstanding the facts show diversity—of race.

Let us now return to the builders of the older earth-works, and consider the possibility of their having been an offshoot of the ancient Mexicans. Of the crania from the most ancient earth-works, we as yet know so little that we can only say that their affinities are with the Toltecan type; but of the character of the art, and particularly the symbolism expressing the religious thought of the people, we can find the meaning only by turning to ancient Mexico. What northern or eastern Indian ever made or can understand the meaning of such sculptures or such incised designs as have been found in several of the ancient ceremonial mounds connected with the great earth-works? What Indian tribe has ever made similar carved designs on human and other bones, or such singular figures, cut out of copper and mica, as were found in the Turner and Hopewell groups? or such symbolic animal forms, elaborately carved in stone, and such perfect terra-cotta figures of men and women as were found on the sacrificial altars of the Turner group? What meaning can be given to the Cincinnati Tablet, or to the designs on copper plates and shell disks from some of the southern and western burial and ceremonial mounds? I think we shall search in vain for the meaning of these many objects in the north or east, or for much that resembles them in the burial places of those regions. On the other hand, most of these become intelligible when we compare the designs and symbols with those of the ancient Mexican and Central American peoples. The Cincinnati Tablet, which has been under discussion for over half a century, can be interpreted and its dual serpent characters understood by comparing it with the great double image known in Mexico as the Goddess of Death and the God of War; the elaborately complicated designs on copper plates, on shell disks, on human bones, and on the wing bones of the eagle, can in many instances be interpreted by comparison with Mexican carvings and with Mexican modes of symbolic expression of sacred objects and religious ideas. The symbolic animals carved on bone or in stone, and the perfection of the terra-cotta figures, point to the same source for the origin of the art.

In connection with the art of the builders, let us consider the earth structures themselves. The great mound at Cahokia, with its several platforms, is only a reduction of its prototype at Chalula. The fortified hills have their counterparts in Mexico. The serpent effigy is the symbolic serpent of Mexico and Central America. The practice of cremation and the existence of altars for ceremonial sacrifices strongly suggest ancient Mexican rites. We must also recall that we have a connecting link in the ancient pueblos of our own Southwest, and that there is some evidence that in our Southern States, in comparatively recent times, there were a few remnants of this old people. It seems to me, therefore, that we must regard the culture of the builders of the ancient earth-works as one and the same with that of ancient Mexico, although modified by environment.

Our northern and eastern tribes came in contact with this people when they pushed their way southward and westward, and many arts and customs were doubtless adopted by the invaders, as shown by customs still lingering among some of our Indian tribes. It is this absorption and admixture of the peoples that has in the course of thousands of years brought all our American peoples into a certain conformity. This does not, however, prove a unity of race.

It is convenient to group the living tribes by their languages. The existence of more than a hundred and fifty different languages in America, however, does not prove a common origin, but rather a diversity of origin as well as a great antiquity of man in America.

That man was on the American continent in quaternary times, and possibly still earlier, seems to me as certain as that he was on the Old World during the same period. The Calaveras skull, that bone of contention, is not the only evidence of his early occupation of the Pacific coast. On the Atlantic side, the recent extensive explorations of the glacial and immediately following deposits at Trenton are confirmatory of the occupation of the Delaware Valley during the closing centuries of the glacial period, and possibly also of the inter-glacial time. The discoveries in Ohio, in Florida, and in various parts of Central and South America, all go to prove man's antiquity in America. Admitting the great antiquity of one or more of the early groups of man on the continent, and that he spread widely over it while in the palæolithic and early neolithic stages of culture, I cannot see any reason for doubting that there were also later accessions during neolithic times, and even when social institutions were well advanced. While these culture epochs mark certain phases in the development of a people, they cannot be considered as marking special periods of time. In America we certainly do not find that correlation with the Old World periods which we are so wont to take for granted.

We have now reached the epoch of careful and thorough exploration and of conscientious arrangement of collections in our scientific museums. It is no longer considered sacrilegious to exhibit skulls, skeletons and mummies in connection with the works of the same peoples. Museums devoted primarily to the education of the public in the æsthetic arts are clearing their cases of heterogeneous collections of ethnological and archæological objects. Museums of natural history are being arranged to show the history and distribution of animal and vegetable life and the structure of the earth itself. Anthropological museums should be similarly arranged, and, with certain gaps which every curator hopes to fill, they should show the life and history of man. To this end, the conscientious curator will avoid the expression of special theories, and will endeavor to present the true status of each tribe or group of man in the past and in the present, so far as the material at his command permits. A strictly geographical arrangement is therefore the primary principle which should govern the exhibition of anthropological collections. A special exhibit may be made in order to illustrate certain methods by which man in different regions has attained similar results, either by contact or by natural means. Another exhibit may be for the purpose of showing the distribution of corresponding implements over different geographical areas. These and similar special exhibits are instructive, and under proper restrictions should be made; but unless the design of each exhibit is clearly explained, the average visitor to a museum will be confused and misled, for such objects so grouped convey a different impression than when exhibited with their associated objects in proper geographical sequence.

The anthropology of America is now being investigated, and the results are being made known through museums and publications as never before.

The thoroughly equipped Jesup North Pacific Expedition, with well-trained anthropologists in charge, was organized for the purpose of obtaining material, both ethnological and archæological, for a comparative study of the peoples of the northern parts of America and Asia. Although only in the third year of its active field work, it has already furnished most important results and provided a mass of invaluable authentic material.

The Hyde Expedition, planned for long-continued research in the archæology and ethnology of the Southwest—a successor in regard to its objects to the important Hemenway Expedition—is annually adding chapters to the story of the peoples of the ancient pueblos.

The results of the extensive explorations by Moore of the mounds of the southern Atlantic coast are being published in a series of important monographs.

The Pepper-Hurst Expedition to the Florida Keys has given information of remarkable interest and importance from a rich archæological field before unknown.

The United States Government, through the Bureau of Ethnology of the Smithsonian Institution, has given official and liberal support to archæological and ethnological investigations in America.

* Address delivered before the American Association for the Advancement of Science, at Columbus, Ohio, on August 21, by Prof. Frederick Ward Putnam, the retiring President of the Association.

The constantly increasing patronage, by wealthy men and women, of archæological research at home, as well as in foreign lands, is most encouraging.

The explorations in Mexico and in Central and South America, the publication in facsimile of the ancient Mexican and Maya codices, the reproduction by casts of the important American sculptures and hieroglyphic tablets, all have been made possible by earnest students and generous patrons of American research.

The numerous expeditions, explorations and publications of the Smithsonian Institution and of the museums of Washington, Chicago, Philadelphia, New York and Cambridge, are providing the student of to-day with a vast amount of authentic material for research in American and comparative anthropology.

The Archæological Institute of America, the American Folk Lore Society, and the archæological and anthropological societies and clubs, in active operation in various parts of the country, together with the several journals devoted to different branches of anthropology, give evidence of widespread interest.

Universities are establishing special courses in anthropology, and teachers and investigators are being trained. Officers of anthropological museums are preparing men to be field workers and museum assistants.

The public need no longer be deceived by accounts of giants and other wonderful discoveries. The wares of the mercenary collector are at a discount, since unauthentic material is considered worthless. Anthropology is now a well-established science. It is required of those who follow any of its branches to do so in seriousness and with scientific methods.

With all this wealth of materials and opportunities there can be no doubt that anthropologists will in time be able to solve that problem which for the last half century has been discussed in this Association — the problem of the unity or diversity of prehistoric man in America.

THE EXPLOSIVE SIDE OF ACETYLENE.

By FREDERICK H. McGAHIE.

WHEN Willson and Moissan adapted the electric furnace a few years ago to the commercial production of calcium carbid at a price low enough to make possible the consideration of acetylene as an illuminant, the attractiveness of the problem was made evident by the numerous applications that soon reached the patent offices. The generation of acetylene by the action of water upon calcium carbid was simplicity itself. The superior illuminating power of the gas was marked. It was practicable to install plants to meet the range of conditions involved in a single house with a few lights up to a large central plant supplying an extensive district. Experiments disclosed certain difficulties such as the need of special burners and complexity of apparatus to secure uniform and reliable generation of the gas, but the thorn that accompanies the rose proved in the case of acetylene to be explosive properties, necessitating provision against certain conditions occurring regularly or accidentally in its production and utilization. In common with the other gaseous illuminants, acetylene forms explosive mixtures with air. But it is in addition unfortunately capable of an explosive decomposition. The early workers had but little scientific data upon the subject to guide them, and paid much attention to highly compressed and liquefied acetylene. The result was that they met with unexpected explosions frequently enough to give the new illuminant a dubious character. However, the recent investigations of foreign scientists, notably Berthelot, Vieille, Lewes, and Pictet, have rehabilitated this character by defining the explosive limits and thus giving the conditions under which acetylene may be used with the same degree of safety that belongs to ordinary illuminating gas.

Acetylene is a stable member of the endothermal explosives. These bodies are formed from their elements with the absorption of heat. In the reverse action of decomposition this heat is set free, so that, if any cause originates molecular decomposition at any point in such a body, the heat evolved thereby will tend to carry on the reaction more extensively and more rapidly. If it proceeds very rapidly and is accompanied by the liberation of much heat and gas, strong explosive phenomena result. The strength of the cause needed to provoke fully this explosive decomposition varies with the molecular stability of the substance in question. The classic endothermal explosive is nitrogen chloride, whose constituent atoms are so loosely united by the bonds of chemical matrimony that a very slight shock is sufficient to grant complete divorce to them. In a careful investigation of its properties, Dulong, its discoverer, gave three fingers and one eye to science. Nitrogen iodide detonates at the touch of a feather. Though acetylene probably liberates in its decomposition much more heat than either of these two bodies, it is fortunately gifted with a high degree of stability.

The calculation of the theoretical pressure and temperature obtainable by the explosion of acetylene itself will illustrate clearly the phenomena of the action. It has an additional interest because all the elements can be taken into account, and figures obtained will agree well with those of experiment. We will start with a molligramme, the molecular weight in grammes. This for acetylene, C_2H_2, is 26 grammes. Consider it confined at atmospheric pressure in a strong vessel and subjected to such action as would induce instantaneous decomposition. This separation into its elements in accordance with the formula—

$$\underset{26\text{ grms.}}{C_2H_2} = \underset{24\text{ grms.}}{C_2} + \underset{2\text{ grms.}}{H_2}$$

has been fully verified. The carbon is thrown down in the amorphous state as a fine soot and the hydrogen appears as a gas having a volume equal to that of the original acetylene. The heat evolved is, according to Berthelot, 51,400 calories for 26 grammes of acetylene. In our hypothetical explosion the reaction is supposed too rapid to permit the loss of any heat to the confining walls, and all would go to raising the temperature of the carbon and the hydrogen. The action taking place at constant volume, the corresponding specific heats are used to calculate the increase of temperature. The range of temperature is too much to allow these heats to be considered constant, and we must employ the expressions given by experiment, in which the specific heat is expressed as a function of the temperature.

The molecular specific heat of hydrogen at constant volume (H_2 = 2 grammes) is given in calories by

$$4·8 + 0·0016\,(t - 1600)$$

t being temperature on Centigrade scale. That for carbon (C_2 = 24 grammes) is

$$8·4 + 0·00144\,t$$

The total increase of temperature is evidently found by solving for t in this equation:

$$\frac{51400}{4·8 + 0·0016\,(t - 1600) + 8·4 + 0·00144\,t} = t$$

It is 2750° C. Since the carbon remains in the solid state during this heating and occupies a volume negligible in comparison with that of the hydrogen—roughly 0·001—the pressure will be that due to raising hydrogen at constant volume 2750° C. above its initial temperature, which will be taken at 15° C., or 288° C. absolute. In this case the pressure is directly proportional to the absolute temperature, and our theoretical pressure becomes $(2750 + 288) \div 288 = 10·55$ atmospheres. If we start with compressed acetylene, it is evident that the pressure due to explosive decomposition is 10·55 times the ratio of the volume of the gas at atmospheric pressure to the reduced volume, the temperature being 15° C. The ratio between the initial pressure and the pressure developed by explosion at constant volume is not constant because the density of acetylene increases more rapidly than the pressure as the gas approaches the point of liquefaction. At 15° C. liquefied acetylene has a volume $\frac{1}{500}$ of that of an equal weight of the gas at atmospheric pressure. Neglecting certain small factors which tend to neutralize one another, the explosion of liquefied acetylene within its own volume gives rise to an approximate theoretical pressure of 5275 atmospheres, or 77,500 pounds per square inch.

These figures point out clearly the need of definite experimental knowledge with regard to this subject. The first observations of value are those made by Berthelot during an exhaustive study of explosives years before acetylene loomed up on the commercial horizon. They deal with the gas under atmospheric pressure. Neither simple heating nor contact with flame nor the action of the electric spark or arc gave rise to explosive effects. At the utmost, a slight local decomposition took place at the exciting point, as evidenced by the precipitation of carbon. A small volume (25 c. c.) confined in a closed tube exploded under the influence of the detonation in its center of 0·1 gramme of mercury fulminate, this explosive giving the most powerfully disruptive shock at our command. When acetylene became an industrial problem, Berthelot and Vieille took up the question anew and confirmed the above facts. Their general conclusion was: "Under atmospheric pressure and at a constant pressure, acetylene does not propagate to an appreciable distance decomposition provoked at any point. Neither the electric spark nor the presence of an incandescent wire, not even the detonation of a fulminate primer, exercises any action beyond the vicinity of the region subjected directly to the heating or the shock."

The limitation to constant pressure in these experiments corresponds to the volumes of practice in which a cause tending to provoke decomposition is rarely liable to increase sensibly the initial pressure through its direct action. Beyond an initial pressure of two atmospheres, acetylene manifests sharply its explosive nature. This table gives the results of some experiments in which explosion was brought about by the incandescence of a platinum wire carried in the center of the testing bomb and heated by an electric current.

Initial Pressure Absolute.	Pressure of Explosion Absolute.	Ratio of Pressures.
2·15 atmospheres.	8·50 atmospheres.	3·9
2·15 "	10·44 "	4·8
3·38 "	18·00 "	5·3
3·38 "	18·71 "	5·6
5·78 "	40·40 "	7·0
5·78 "	42·03 "	7·2
10·87 "	89·76 "	8·2
10·87 "	88·80 "	8·0
20·45 "	206·77 "	10·1
20·45 "	205·70 "	10·1

The velocity of the reaction increased rapidly with the initial pressure, and it is interesting to note that at 20·45 atmospheres the measured pressure of explosion agrees quite well with that indicated by theory. At the low pressures the velocity of decomposition is relatively slow and a certain amount of heat is lost to the walls of the bomb. With a higher initial pressure this loss decreases with increase of the velocity of reaction, and at the same time there is a larger weight of gas in the bomb to show still less the effects of the heat loss.

It is not possible to define a critical pressure above which a definite exciting cause will always make acetylene explode and below which it will not. Between these two points there is an uncertain range in which explosion may or may not occur. In recent work Berthelot and Vieille have sought to establish the pressures which may be considered free from danger. They put the maximum pressure allowable at 10·5 pounds gage when the exciting cause is the presence of an incandescent wire in the gas and 3·5 pounds when it is the detonation of a fulminate cap. These two methods of provoking explosion were taken as representative of extreme conditions it was supposed possible to exist in bad practice. The first method corresponds to intense local heating which may occur in calcium carbid attacked by a small amount of water or in valves possibly through intense friction. The second method would be realized in the formation and subsequent detonation of certain metallic acetylides. Lewes has shown that when the water admitted to the carbid is employed in quantities based only upon the reaction giving acetylene, the carbid may have local temperatures as high as 1450° F. The scientific type of generator, coinciding in both safety and economy, is that in which the carbid is fed in determinate amounts into an excess of water capable of absorbing the heat liberated with but a slight elevation of temperature. The economical objection to high temperatures is that acetylene begins to be transformed around 1100° F. into polymeric compounds affecting the illuminating power. A deterioration of 50 per cent. has been noted by Lewes in bad cases. The belief held first that acetylene would directly attack certain metals, especially copper and its alloys, to form explosive acetylides has been proved wrong by several investigators. The production of these salts requires conditions not met with in practice but which must be supplied artificially in the laboratory. It is generally conceded that nothing need be feared in this direction.

In view of the above facts, liquefied acetylene is naturally quite susceptible to explosion on account of its condensed state. High temperatures, sparks, or heavy shocks to the liquid itself will cause detonation. In one experiment by Berthelot a steel bomb was filled with 18 grammes of liquefied acetylene and detonated by the incandescent wire method. The pressure indicated by the crusher gage was 5383 atmospheres. On the other hand, Berthelot and Vieille have shown that cylinders carrying liquefied acetylene are safe against heavy shocks. They employed steel cylinders of one liter capacity. Some were charged with acetylene gas compressed to 10 atmospheres and the others with 300 grammes of liquefied acetylene. Both types were allowed to fall repeatedly from a height of 19·5 feet upon a steel block. No explosion followed. When the cylinders were broken by a weight of 616 pounds falling from the same height upon them, neither inflammation nor explosion resulted in the case of the compressed gas. With liquefied acetylene an explosion followed rupture, but it was attributed not to the detonation of the acetylene itself but to the inflammation of a mixture of the gas with air formed at the moment of the rupture and ignited by sparks caused by the grinding upon each other of the broken pieces of metal. The cylinder sustains no further crushing beyond that due to the falling weight, while the detonation of liquefied acetylene breaks the cylinders up into many small pieces, a characteristic action of high explosives. This immunity of charged cylinders against shock has been verified by factory explosions in which cylinders standing near the one that exploded have been thrown about with great violence without detonation of their contents. Liquefied acetylene will detonate through any cause whose ultimate effect is to raise the temperature to a degree involving decomposition, its density allowing this local effect to be propagated explosively through the entire mass. A shock to a charged cylinder does not mean the same to the contained liquid. The energy of a direct blow to the liquid may be transformed into the heating of but a small portion, while the same blow to the cylinder means the transmission to the liquid of but a slight fraction of its energy, whose effect is moreover minimized in being absorbed by the total liquid mass. The dangerous possibilities of any liquefied acetylene system are well illustrated by the following explanation advanced to account for certain accidents. The cylinder valve was opened too quickly, permitting a large volume of gas to rush out with considerable velocity. When this gas was suddenly arrested by the reducing valve, the head of the column was compressed adiabatically to an extent producing a temperature high enough to cause explosion.

The present attitude of municipal and insurance authorities is indicated by the regulations of the National Board of Fire Underwriters, which prohibit absolutely the use of liquid acetylene or gas generated therefrom and place the maximum pressure allowable in generators at 3 pounds gage.

This explosive decomposition should not be confounded with the effects following the rupture of charged cylinders. This latter case is analogous to the explosion of steam boilers and ammonia tanks in which the liquid flashes suddenly into a large volume of gas with the release of pressure.

In forming explosive mixtures with air, acetylene is more dangerous than illuminating gas. The ignition temperature is lower; the explosive energy is greater; and the range of the proportions of gas and air is wider. When air is mixed increasingly with a combustible gas, a point is soon reached at which a flame or a spark inflames the mixture, the inflammation proceeding slowly through the whole mass. The reaction is too slow and the energy developed too small to give rise to explosive effects, the danger consisting of the ignition of combustible matter. As the proportion of air increases, detonating mixtures are obtained whose explosive energy increases up to a certain point, theoretically given by the volume of air which supplies just enough oxygen for complete combustion of the gas. From this maximum the explosive power of the mixtures decreases, becoming simply inflammable again and then non-inflammable. The observed limits of inflammability vary somewhat with different investigators on account of differences in initial conditions. Le Chatelier states that the acetylene mixtures begin to be inflammable when the volume percentage of acetylene is 2·8 per cent., and cease to be so when it is over 65 per cent. Ravel's experiments give the limits of explosive mixtures as 4·8 per cent. and 43 per cent. of acetylene by volume. Grehant compared it with illuminating gas, his observations being condensed in the following tables:

ACETYLENE.

VOLUMES.		REMARKS.
Acetylene	Air.	
1	1	Burns with sooty flame.
1	2	" "
1	3	Explosion with deposit of carbon.
1	4	Stronger explosion without deposit of carbon.
1	6	Strong explosion.
1	9	Strongest "
1	12	Strong "
1	19	Weak "
1	20	Inflammation without explosion.
1	25	" " "

ILLUMINATING GAS.

VOLUMES.		REMARKS.
Gas.	Air.	
1	1	Does not burn.
1	2	" "
1	3	Explosion.
1	6	Strongest explosion.
1	11	Weak explosion
1	12	Inflammation.

The temperature of ignition of the mixtures of a combustible gas with air is fairly constant in spite of varying proportions. Le Chatelier places it for acetylene in the neighborhood of 900° F. as against 1100° F. for the greater part of combustible gases.

The strong explosiveness of the acetylene mixtures arises from its large heat of combustion. The complete combustion of one pound of acetylene as given by

$$C_2H_2 + 2{\cdot}5O_2 = 2CO_2 + H_2O$$

develops 21,635 British thermal units, of which 18,200 are due to the oxidation of the carbon and the hydrogen, the balance being contributed by the separation of acetylene into its elements. Many experiments by E. G. Love make the average calorific power of New York city gas 710 heat units per cubic foot at 62° F. and 30 inches barometer. Under these conditions acetylene gives some 1,515 heat units per cubic foot. Twelve volumes of air supply the theoretical amount of oxygen necessary for the complete combustion of one volume of acetylene. Theoretical calculations of the temperature and pressure obtaining in such a case are not satisfactory, as the indeterminate effects of dissociation can not be allowed for. When explosion accompanies rapid combustion, the temperature is limited by that at which the complex products are not capable of existing. In absence of data upon the air mixtures, we may form some idea of actual pressures obtaining by exploding combustible gases with just enough pure oxygen to give complete combustion. The principal combustibles of illuminating gas are CO, CH_4, and H. Experiments have given these pressures for the conditions indicated, corresponding to development of maximum energy:

Gas.	Pressure.
Hydrogen—H	9·6 atmospheres.
Carbon monoxide—CO	9·4 "
Methane—CH_4	13·6 "
Acetylene—C_2H_2	13·7 "

These are the facts that render it necessary that scientific and practical knowledge go hand in hand in order that acetylene may be safely utilized as an illuminant.

MANUFACTURE OF BORACIC ACID AND AMMONIA BY TREATING BORATES WITH AMMONIUM SALTS, AND OF BORAX AND AMMONIUM NITRATE BY TREATING AMMONIUM BORATE WITH SODIUM NITRATE.

By Dr. BIGOT.

BY treating the borates, for instance lime borate, with an ammonium salt, for instance ammonium sulphate, ammonium borate is formed:

$$(NH_4)\,2\,SO_4 + Ca\,B_2O_4 = (NH_4)\,2\,B_2O_4 + Ca\,SO_4.$$

But if the heating is continued, provided the mixture contains the ammonium salt in excess, the ammonium borate is decomposed into boracic acid dissolved in the water and ammonia, which is evaporated.

Until now, this reaction has not been known. It permits the separation of the boracic acid from its base in a manner which economizes the acid, whether sulphuric or hydrochloric, by obtaining ammonia at the same time:

$$(NH_4)\,2\,B_2O_4 = B_2O_3 + 2\,NH_3.$$

The following is the method of operating: 100 parts of lime borate are treated with 150 parts of ammonium sulphate. They are heated for several hours in a closed apparatus, allowing the collection of the ammonia. The insoluble calcium sulphate is separated from the lixivium, which contains the boracic acid in solution. On cooling the boracic acid will crystallize.

Following is the method of producing borax at the same time with ammonium nitrate:

Ammonia and sodium nitrate are added to the boracic acid in quantities corresponding to the formula—

$$2\,B_2O_3 + 2\,NH_3 + Na_2HN_2O6.$$

The mixture is heated, and after the materials are dissolved in a quantity of water, the least possible borax is formed, a salt not readily soluble, and ammonium nitrate, a salt quite soluble, which remains in the solution:

$$(Na)_2\,B_4O\,7 + (NH_4)\,2\,N_2O_6.$$

This process saves the sodium carbonate and produces by the same operation ammonium nitrate cheaply and more readily purified.—La Revue des Produits Chimiques.

British Harvest.—Under date of September 9, 1899, Consul Halstead, of Birmingham, transmits the following forecast of the harvest, from The London Daily Mail:

Both hay and oats are much better crops in Ireland this year than they have proved to be in Great Britain. The same result occurred last year.

The hay harvest in Great Britain is worse than was anticipated. The yield is estimated at 23 cwts. (1·15 tons)* per acre, the total crops being 150,740,000 cwts. (7,537,000 tons), which is 50,000,000 cwts. (2,500,000 tons) below last year's and about 11,000,000 cwts. (550,000 tons) below the average for the last ten years.

Wheat is regarded as a good average crop, while barley and oats are but moderate. The wheat yield is about 30 bushels per acre; barley, 32 bushels per acre; and oats, 35 bushels per acre.

Taken as a whole, and looking also at the poor root crops and the drying up of the pastures during the summer grazing season, it is clear that 1899 has been a poor year for the stock farmer, dairyman, and grazier, and only a moderate one for the corn grower. For the latter, also, prices are poor, the only grain now selling well being the better qualities of barley.

* British tons of 2,240 pounds.

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TABLE OF CONTENTS.